final environmental impact statement

U.S. DEPARTMENT OF THE INTERIOR

BUREAU OF LAND MANAGEMENT

CRUDE OIL TRANSPORTATION SYSTEM: VALDEZ, ALASKA TO MIDLAND, TEXAS

(AS PROPOSED BY SOHIO TRANSPORTATION COMPANY)

CHAPTER 8
ALTERNATIVES TO THE PROPOSED ACTION
GLOSSARY
CONVERSION TABLE
APPENDICES

FINAL

ENVIRONMENTAL STATEMENT

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GLOSSARY

CONVERSION TABLE

APPENDICES

Prepared by

Bureau of Land Management
U.S. Department of the Interior

TABLE OF CONTENTS

CHAPTER 8

ALTERNATIVES TO THE PROPOSED ACTION

Section	Title	Page
8.0	SUMMARY OF ALTERNATIVES AND RESPECTIVE IMPACTS	8-1
8.0.1	Ports, terminals and pipelines	8-1
8.1	NO ACTION/DELAYED ACTION/TRANSPORT ENTIRELY BY TANKER ALTERNATIVES	8-8
8.1.1	No-action alternative	8-8
8.1.2	Delayed action	8-10
8.1.3	Transport entirely by tanker	8-11
8.1.3.1	Shipment around Cape Horn to the Gulf Coast	8-11
8.1.3.2	Shipment through the Panama Canal to U.S. Gulf of Mexico coast	8-13
8.1.4	Transport by tanker with use of existing Navy pipelines, Panama Canal	8-15
8.2	PORTS OF ENTRY AND PIPELINE ROUTING ALTERNATIVES	8-16
8.2.1	Kitimat, British Columbia (Port) to Edmonton, Alberta, Canada	8-17
8.2.1.1	Port of Kitimat, British Columbia, Canada	8-17
8.2.1.2	Kitimat, British Columbia, Canada to Edmonton, Alberta, Canada, pipeline	8-22
8.2.2	Cherry Point, Washington to Edmonton, Alberta	8-25
8.2.2.1	Port of Cherry Point	8-25
8.2.2.2	Cherry Point, Washington, to Edmonton, Alberta, pipeline	8-31
8.2.3	Puget Sound, Washington, to Clearbrook, Minnesota	8-32
8.2.3.1	Port Angeles, Washington	8-33
8.2.3.2	Puget Sound, Washington, to Clearbrook, Minnesota, pipeline	8-37
8.2.4	Puget Sound, Washington, to Sidney, Nebraska	8-45
8.2.4.1	Puget Sound to Sidney, Nebraska, pipeline	8-45
8.2.5	Central coast, California, to Sidney, Nebraska	8-48
8.2.5.1	Estero Bay port	8-48
8.2.5.2	San Luis Obispo Bay, California, port alternatives (Avila Beach, Oso Flaco, or Guadalupe Dunes)	8-56
8.2.5.3	Central California coast to Sidney, Nebraska, pipeline corridor	8-62

TABLE OF CONTENTS

CHAPTER 8 (Continued)

Section	Title	Page
8.2.6	Central California coast to Midland, Texas	8-67
8.2.7	Ventura County, California, to Midland, Texas	8-69
8.2.7.1	Port Hueneme/Oxnard and Deer Creek (Ventura County), California	8-69
8.2.7.2	Port Hueneme (Ventura County), California, to Midland, Texas	8-74
8.2.8	Camp Pendleton, California, to Midland, Texas	8-75
8.2.8.1	Camp Pendleton, California, port alternative	8-75
8.2.8.2	Camp Pendleton to Midland pipeline corridor	8-79
8.2.9	Trans-Guatemala pipeline	8-81
8.3	RAIL TRANSPORT ALTERNATIVE	8-81
8.4	ALTERNATIVE OF ALL NEW PIPELINE CONSTRUCTION IN PROPOSED CORRIDOR	8-84
REFERENCES		8-86
GLOSSARY		G-3
CONVERSION TABLE		C-3

APPENDICES

Appendix	Title	Page
A1.0	Geotechnic Evaluation -- Pipeline Route	A-5
A1.1.1.1	Equipment and Operations of Tankers (Including Inert Gas Systems)	A-59
A1.1.1.1-A	Tanker Traffic Study	A-85
A1.2.3.2	Hydrostatic Test Procedure	A-179
A2.1.3.2	Geology	A-211
A2.1.4.1	Soil Samplings and Related Tables	A-227
A2.1.5.2	Water Resource Tables	A-263
A2.1.5.4	Water Quality Standards	A-313
A2.1.8.1	Birds of the Southern California Bight Areas	A-339
A2.1.8.1.3	Zooplankton and Marine Fish, Los Angeles-Long Beach Harbor	A-357

TABLE OF CONTENTS

APPENDICES (Continued)

Appendix	Title	Page
A2.1.8.1.3-A	Fishery Production Summary	A-389
A2.1.8.2	Species Occurring Within Major Biomes or Aquatic Areas Along the Pipeline Route	A-397
A2.1.8.3	Threatened, Rare, Endangered, or Protected Species Along the Sea Leg and the Proposed Pipeline Route	A-441
A2.1.9.3	Recorded Archaeological Resources in California -- Pipeline Route	A-453
A2.1.12.6	Land Uses and Special Features Along the Proposed Pipeline Route	A-459
A3.1.6	Methodology of Impact Analysis	A-473
A3.1.6.1	Emissions Calculations	A-489
A3.1.6.1.2	State of California Air Resources Board, Resolution 76-39, October, 1976	A-517
A3.1.11	Propagation Model and Source Levels	A-535
A3.1.11.1.1	Worst Case Construction Scenario, Dominguez Hills Terminal	A-543
A3.1.11.1.2	Assessment of Noise From Pump Stations	A-547
A3.1.11.2.1	Noise Levels From Pipeline Construction	A-555

LIST OF FIGURES

CHAPTER 8

Figure	Title	Page
8.0-1	Alternate crude oil transportation systems	8-2
8.2.1-1	Port and pipeline alternatives; Kitimat Edmonton (proposed) Cherry Point Edmonton (existing)	8-18
8.2.3.2-1A	Port and pipeline alternatives; Puget Sound, Washington, to Clearbrook, Minnesota	8-38
8.2.3.2-1B	Port and pipeline alternative; Puget Sound, Washington, to Clearbrook, Minnesota	8-39
8.2.3.2-1C	Port and pipeline alternatives; Puget Sound, Washington, to Clearbrook, Minnesota	8-40
8.2.5-1A	Port and pipeline alternatives; central California coast to Sidney, Nebraska	8-49
8.2.5-1B	Port and pipeline alternatives; central California coast to Sidney, Nebraska	8-50
8.2.7-1	Port and pipeline alternatives; central California coast, Port Hueneme/Oxnard and Camp Pendleton tie-in to Elk Hills	8-70

APPENDICES

A1.0	Geotechnic Evaluation -- Pipeline Route figures:	
1H-1	Fault tree analysis -- crude oil spill potential	A-31
1H-2	Fault tree analysis -- terminal effluent system failure	A-32
1H-3	Fault tree analysis -- pump station effluent system failure	A-33
1H-4	Fault tree analysis -- pump spill	A-34
1H-5	Fault tree analysis -- tank spill	A-35
1H-6	Fault tree analysis -- pipeline rupture	A-36
1H-7	Fault tree analysis -- pipeline leak	A-37
A1.1.1.1-1	Gas displacement when loading cargo	A-62
A1.1.1.1-2	Operative inert gas when discharging cargo	A-64
A1.1.1.1-3	Gas-freeing, using the inert gas flow	A-65
A1.1.1.1-4	Sun Shipbuilding Company 120,000-ton ecological tankers	A-68

LIST OF FIGURES

APPENDICES (Continued)

Figure	Title	Page
A1.1.1.1-5	Avondale Shipyards Company 165,000-ton segregated ballast tanker	A-69
A1.1.1.1-A:	Tanker Traffic Study figures:	
5-1	Possible sources of oil pollution during tanker operation	A-103
5-2	Vertical extent of grounding damage versus tanker beam	A-119
5-3	Location of reported icebergs, June 8 to September 5, 1976	A-127
5-4	Distance icebergs observed drifting from Columbia Glacier, June 8 to September 5, 1976	A-128
5-5	Accident probability Pa (per voyage) for collision with icebergs	A-128
5-6	Approaches to Port Valdez, Alaska	A-134
5-7	Approaches to Europort, Rotterdam, The Netherlands	A-135
5-8	Approaches to Finnart, Scotland	A-136
5-9	Approaches to Milford Haven, Wales	A-137
5-10	Mean monthly pressure and storm tracks, northeastern Pacific -- January	A-145
5-11	Mean monthly pressure and storm tracks, northeastern Pacific -- July	A-146
B-1	Basis for calculation of ship collision model	A-174
A3.1.6-1	Selected trajectories for oxidant impact of terminal facilities	A-476
A3.1.11.1.1-1	Predicted noise level vs. distance from terminal construction site	A-544
A3.1.11.1.2-1	Sound-level directivity pattern of main-line pumping units	A-548
A3.1.11.1.2-2	Main-line pumping unit octave band noise levels	A-549
A3.1.11.1.2-3	Predicted noise level vs. distance from operating main-line pump station	A-551
A3.1.11.2.1-1	Construction spread scenarios	A-556
A3.1.11.2.1-2	Noise levels from urban pipeline construction scenario	A-557

LIST OF FIGURES

APPENDICES (Continued)

Figure	Title	Page
A3.1.11.2.1-3	Noise levels from suburban pipeline construction scenario	A-558
A3.1.11.2.1-4	Approximate period during which indicated construction noise level is exceeded	A-559

LIST OF TABLES

CHAPTER 8

Table	Title	Page
8.0.1-1	Alternative Port and Pipeline Terminals	8-3
8.0.1-2	Port Alternatives	8-5
8.0.1-3	Comparative Summary of Pipeline Alternatives	8-6
8.3.1-1	Tank Cars Needed for Unit Train Operations, Port Westward, Oregon, to Minot, North Dakota	8-83

LIST OF TABLES

APPENDICES

A1.0-1	Record of Fabricated Pipe Failures Found During Testing	A-10
A1.1.1.1-1	Component Parts of the Inert Gas System	A-60
A1.1.1.1-2	SOHIO Tanker Fleet Statistics	A-66
A1.1.1.1-A:	Tanker Traffic Study Tables:	
5-1	Accident Types	A-109
5-2	Accident Locations	A-110
5-3	SOHIO Fleet Composition For Delivery of 700,000 bbl/d to Long Beach	A-111
5-4	Accidents per Voyage, World Tanker Fleet 1969-1970	A-114
5-5	Accidents per Voyage, Estimates for the SOHIO Fleet	A-116
5-6	SOHIO Fleet Aggregated i and j Values From Table 5-5	A-117
5-7	Probability of an Oil Spill After a Tanker Accident, World Tanker Fleet 1969-1970	A-120
5-8	Probability of an Oil Spill After a Tanker Accident, SOHIO Fleet	A-120
5-9	Probability of Total Vessel Loss S and Spill Volumes, World Tanker Fleet 1969-1970	A-121
5-10	Values of P Obtained From References	A-124
5-11	Summary of Results of Tanker Simulation Runs	A-140

LIST OF TABLES

APPENDICES (Continued)

Table	Title	Page
5-12	Average Number of Hours of Operation of Fog Signals	A-151
5-13	Extreme Weather Conditions at Ocean Station "p"	A-152
5-14	Probability per Year of Total Vessel Loss, Loaded Condition Only	A-165
5-15	Probability of a Spill per Trip P for Each Vessel Type	A-165
5-16	Probability per Year of Spills With Less Than Total Vessel Loss With Average Spill Volumes	A-166
5-17	Probability per Year of Spill for All Casualties With Average Spill Volume	A-166
5-18	Probability of k Total Vessel Losses Over a 25-Year Project Life	A-167
5-19	Yearly Probability of a Spill by Casualty Type, Entire Fleet	A-168
5-20	Comparison of Present Results With Those of Socio-Economic Systems for Yearly Accidental Spill Volumes	A-169
A2.1.3.2-1	Major Historic Earthquakes and Surface Faulting in Southern California	A-211
A2.1.3.2-2	Summary of Quarternary Faults in the Vicinity of the Pipeline route -- Arizona, New Mexico, Texas	A-222
A2.1.4.1-1	Sediment Chemistry Results of Core Samples	A-227
A2.1.4.1-2	Water Depth at Sediment Core Sampling Stations	A-245
A2.1.4.1-3	Sediment Chemistry Results of Grab Samples	A-246
A2.1.4.1-4	Statistical Analyses of Replicate Core Samples	A-247
A2.1.4.1-5	Quarterly Measurements of Sediment Quality Within Long Beach Harbor in 1974	A-251
A2.1.4.1-6	Characteristics of Grain Size Distribution Curves at Benthic Stations	A-255
A2.1.4.1-7	Comparison of Surface Samples in Long Beach Harbor and Vicinity (ppm)	A-257

LIST OF TABLES

APPENDICES (Continued)

Table	Title	Page
A2.1.4.1-8	Nutrient Levels in Sediments Within Long Beach Harbor	A-259
A2.1.5.2-1	Surface Water Features Encountered in California by the Proposed Project	A-263
A2.1.5.2-2	Surface Water Features Encountered by the Proposed Pipeline Project East of California	A-266
A2.1.5.2-3	Streamflow Data for South Coastal Basin, Lower Colorado River and Great Basin	A-268
A2.1.5.2-4	Water Quality Data for Los Angeles River at Pacific Coast Highway, Long Beach, California	A-270
A2.1.5.2-5	1967 Water Quality of Selected Los Angeles River Basin Streams	A-271
A2.1.5.2-6	Water Quality Data for San Gabriel River at Whittier Narrows, California	A-274
A2.1.5.2-7	1967 Water Quality Data of Selected Santa Ana River Basin Streams	A-275
A2.1.5.2-8	Water Quality Data for Santa Ana River Below Prado Dam, California	A-277
A2.1.5.2-9	Water Quality Data for Santa Ana River at Colton, California	A-278
A2.1.5.2-10	Water Quality Data for Whitewater River at White Water, California	A-279
A2.1.5.2-11	Representative Water Quality of Coachella Valley Streams	A-280
A2.1.5.2-12	Water Quality Data For Colorado River Below Cibola Valley, Arizona	A-281
A2.1.5.2-13	Goundwater Resources Inventory for the South Coastal Basin	A-282
A2.1.5.2-14	Records of Selected Wells	A-283
A2.1.5.2-15	Chemical Analyses of Water From Selected Wells	A-291
A2.1.5.4-1	Trace Constituents -- Los Angeles River Basin	A-313
A2.1.5.4-2	Mineral Quality Objectives for Surface Waters -- Los Angeles River Basin	A-314

LIST OF TABLES

APPENDICES (Continued)

Table	Title	Page
A2.1.5.4-3	Water Quality Objectives for Los Angeles River Basin Surface Waters	A-315
A2.1.5.4-4	Limiting Concentrations of Inorganic Chemicals for Colorado River Basins	A-319
A2.1.5.4-5	Limiting Fluoride Concentrations for Colorado River Basins	A-320
A2.1.5.4-6	Limiting Concentrations of Chemicals in Discharges of Wastes to Surface Waters in Colorado River Basins	A-321
A2.1.5.4-7	Mineral Quality Objectives for Groundwater in the Los Angeles/San Gabriel Hydrographic Unit	A-322
A2.1.5.4-8	Groundwater Quality Objectives in the Santa Ana River Basin	A-322
A2.1.5.4-9	Trace Constituents Santa Ana River Basin	A-323
A2.1.5.4-10	Selected Chemical Groundwater Quality Objectives for East and West Colorado River Basins	A-324
A2.1.5.4-11	Limits of Toxic Substances in Industrial and Domestic Uses	A-325
A2.1.5.4-12	Limits of Toxic Substances in Agricultural Uses	A-327
A2.1.5.4-13	Limits of Toxic Substances for Fish, Aquatic Life, and Wildlife Uses	A-330
A2.1.5.4-14	Standards for Domestic and Livestock Watering Use	A-331
A2.1.5.4-15	Standards for Irrigation Use	A-332
A2.1.5.4-16	Texas Water Quality Standards	A-333
A2.1.5.4-17	State Approved Water Quality Standards for Coastal Waters	A-334
A2.1.8.1-1	Birds of the Southern California Bight -- Coastal and Offshore Regions	A-339
A2.1.8.1-2	Birds of the Southern California Bight -- Ocean Shoreline	A-344
A2.1.8.1-3	Birds of the Southern California Bight -- Saltmarshes and Estuaries	A-348

LIST OF TABLES

APPENDICES (Continued)

Table	Title	Page
A2.1.8.1.3-1	Zooplankton Species, Los Angeles-Long Beach Harbors	A-357
A2.1.8.1.3-2	Principal Marine Fish Found in Los Angeles-Long Beach Harbors	A-368
A2.1.8.2-1	Reptiles Existing or Potentially Occurring Within Major Biomes in the Vicinity of the Proposed Pipeline Route	A-397
A2.1.8.2-2	Amphibians Existing or Potentially Occurring in the Vicinity of the Proposed Pipeline Route	A-405
A2.1.8.2-3	Birds Existing or Potentially Occurring Within Major Biomes in the Vicinity of the Proposed Pipeline Route	A-407
A2.1.8.2-4	Mammals Existing or Potentially Occurring Within Major Biomes in the Vicinity of the Proposed Pipeline Route	A-425
A2.1.8.2-5	Fishes Existing or Potentially Occurring in the Vicinity of the Proposed Pipeline Route	A-433
A2.1.8.3-1	Threatened, Rare, and Endangered Marine Mammals Along the Sea Leg	A-441
A2.1.8.3-2	Rare and Endangered Species of Birds Along the Sea Leg	A-442
A2.1.8.3-3	Rare, Threatened, Endangered, and/or Protected Vertebrates Which May Occur in the Vicinity of the Proposed Pipeline Route	A-444
A2.1.9.3-1	Recorded Archaeological Resources Along Pipeline Route in California	A-453
A2.1.12.6-1	Special Features Within the Proposed Pipeline Corridor, San Pedro Bay to Pomona	A-459
A2.1.12.6-2	Special Features Within the Proposed Pipeline Corridor, Pomona to Ehrenberg	A-462
A3.1.6-1	Meteorological Data at Long Beach, 1 March 1975	A-482
A3.1.6.1-1	Calculation of Standing Loss From One Typical Tank	A-490
A3.1.6.1-2	Calculation of Withdrawal Loss From One Typical Tank	A-491
A3.1.6.1-3	Total Emissions From Storage Tanks at Proposed Sites	A-492

LIST OF TABLES

APPENDICES (Continued)

Table	Title	Page
A3.1.6.1-4	Tankship Physical and Operational Data	A-493
A3.1.6.1-5	Steamship Emission Factors (lb/1,000 gal)	A-494
A3.1.6.1-6	Pollutant Emission Rates From Tankship Operations in Long Beach Harbor	A-494
A3.1.6.1-7	Crude Oil Vapor Composition by Volume, Mass, and Reactivity	A-495
A3.1.6.1-8	Basic SOHIO Tanker Fleet Capacity	A-496
A3.1.6.1-9	Case A, 1980 Worst Case Fleet	A-497
A3.1.6.1-10	Case B, 1980 Best Case Fleet	A-498
A3.1.6.1-11	Emission Factors for Heavy-Duty Vehicles (lb/1,000 gal)	A-502
A3.1.6.1-12	Construction Estimates for use in Emission Calculations	A-503
A3.1.6.1-13	Average Emissions Resulting From Construction Equipment (lb/d)	A-504
A3.1.6.1-14	Fugitive Dust Emissions for Terminal and Pump Station Construction	A-506
A3.1.6.1-15	Fugitive Dust Emissions for Pipeline Segments	A-506
A3.1.11-1	Computer Inputs and Outputs -- ERTNOI	A-536
A3.1.11-2	dBA Summation Chart for Two Sources	A-537
A3.1.11-3	Noise Emission Characteristics of Pipeline and Pump Station Construction Equipment	A-538
A3.1.11.2.1-1	Computed Duration of Possible Noise Impact as a Function of Existing Noise Level	A-560

CHAPTER 8

ALTERNATIVES TO THE PROPOSED ACTION

8.0 SUMMARY OF ALTERNATIVES AND RESPECTIVE IMPACTS

8.0.1 Ports, terminals, and pipelines

Beginning in 1978 when North Slope Prudhoe Bay crude oil production is expected to reach 1.2 million bbl/d, a surplus of crude oil is predicted to develop on the West Coast. Under stipulations of the Trans-Alaska Pipeline Act, no crude oil transported through the Trans-Alaska Pipeline may be shipped to foreign markets without Presidential approval and Congressional review. The applicant has a combination of options for moving SOHIO's 54 percent share of the projected 1.2 million bbl/d of oil from Valdez, Alaska, to markets east of the Rocky Mountains. Oil could be shipped via tanker to West Coast ports and thence via existing railroad tank cars and existing oil product lines. The capacity to ship oil via existing railroad tank cars is somewhat limited by the numbers of these cars available and the expense of rail shipment. The use of existing product lines, such as the Four Corners pipeline, is also somewhat limited because of a 16-inch line diameter and hence limited throughput capacity.

Alternative crude oil systems are shown in Figure 8.0.1-1. Port and pipeline terminal areas which are presented as alternatives to the applicant's proposed Long Beach, California, to Midland, Texas, project are displayed in Table 8.0.1-1 and analyzed in Section 8.2.

It would be noted that the total Prudhoe Bay output will be shipped from Valdez to one or more destinations whether or not the present SOHIO proposal is implemented. Should the proposal be implemented with Long Beach as the

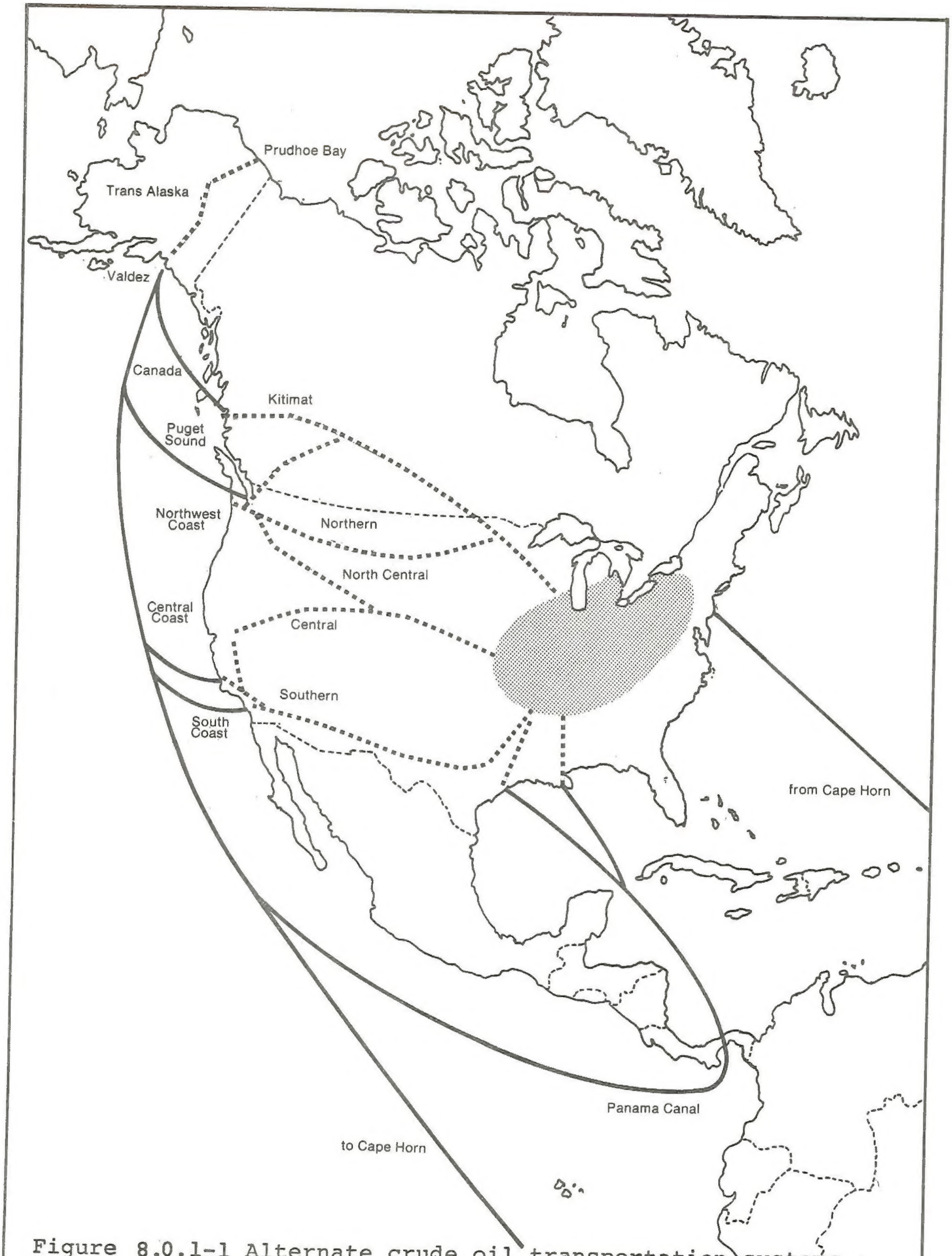


Figure 8.0.1-1 Alternate crude oil transportation systems

port terminal, other ports could be selected as terminals for the remainder of the Prudhoe Bay output (shares other than SOHIO's).

TABLE 8.0.1-1

Alternative Port and Pipeline Terminals

PORT TERMINAL	Pipeline Terminus[a]
1. Kitimat, British Columbia, Canada	Edmonton, Alberta
2. Cherry Point, Washington	Edmonton, Alberta
3. Puget Sound, Washington Port Angeles or Cherry Point	Clearbrook, Minnesota
4. Puget Sound, Washington Port Angeles or Cherry Point	Sidney, Nebraska
5. Central coast, California Estero Bay Avila Beach Oso Flaco or Guadalupe Dunes	Sidney, Nebraska
6. Central coast, California Estero Bay Avila Beach Oso Flaco or Guadalupe Dunes	Midland, Texas
7. Ventura County, California Port Hueneme/Oxnard or Deer Creek	Midland, Texas
8. Camp Pendleton, California	Midland, Texas
9. Trans-Guatemala Pipeline	

[a] Tie into existing crude oil pipeline distribution network.

Each port would be linked to the Midwest by pipeline. Estero Bay, Avila Beach, Oso Flaco, Port Hueneme/Oxnard, Deer Creek, and Camp Pendleton would utilize offshore unloading facilities (monobuoys) and would not involve

dredging or docking facility construction. Use of monobuoys would involve higher risks of spills and possibly interrupted service as a result of occasional adverse weather and sea conditions and the less protected berthing situation. In general, ports and facilities in California would have greater risk of spills from earthquakes and would have greater potential air pollution problems. In addition to the Port of Long Beach, only the alternative ports of Kitimat, Port Angeles, and Cherry Point are characterized as existing industrial port areas; new berthing facilities, but little or no dredging, would be required. See Table 8.0.1-2 for a comparative summary of port alternatives.

Table 8.C.1-2

Port Alternatives

PORT	Tanker Off-loading Facility	Existing Industrial Land Uses	Inland Passage Mileage
Kitimat, British Columbia, Canada	Berths	Pulp mill and aluminum plant	280 miles (on fjord)
Cherry Point, Washington	Berths	Refinery and nearby aluminum plant	140 miles (within Puget Sound)
Port Angeles, Washington	Berths	Pulp mill and lumber mills	80 miles (entrance to Puget Sound)
Estero Bay, California	Monobuoy	None except for small petroleum tankage	0
Avila Beach, California	Monobuoy	None except for small petroleum tankage	0
Osc Flaco, California	Monobuoy	None, small refinery inland	0
Guadalupe Dunes, California	Monobuoy	None	0
Port Hueneme/Oxnard, California	Monobuoy	Naval base, limited industrial development inland	0
Deer Creek, California	Monobuoy	None	0
Camp Pendleton, California	Monobuoy	None on Marine Corps base except nuclear power plant	0

Those pipelines involving the longest new construction and those involving segments not closely paralleling existing transportation and utility rights-of-way would generally have greater environmental impacts. See Table 8.0.1-3 for comparative summary of pipeline alternatives.

Table 8.0.1-3

Comparative Summary of Pipeline Alternatives

PORT	Pipeline Terminus	Total Pipeline Mileage	New Utility Corridor Mileage[a]	Pipeline Construction Mileage in Urbanized Areas	Pipeline Construction Mileage in Mountainous Areas	Major River Crossings	New Pipeline Construction Mileage in Parks, National Forest, Wildlife Refuges, Indian Reservations
Kitimat, British Columbia	Edmonton, Alberta	780	0	2	465	13	90
Cherry Point, Washington	Edmonton, Alberta	(730)[b]	0	0	0	unknown	0
Puget Sound, Washington	Clearbrook, Minnesota	1680	780	20	280	31	160
Puget Sound, Washington	Sidney, Nebraska	1400	590	20	290	18	80
Central California Coast	Sidney, Nebraska	1260	290	4	220	19	60
Central California Coast	Midland, Texas	430+ (800)	210	20	20	4+(4)	31-34
Port Hueneme, California Coast	Midland, Texas	300+ (797)	150	20	15	3+(4)	31
Long Beach, California	Midland, Texas	237 (789)	132	80	0	5+(4)	16

[a] Removed from existing ROWs by one-quarter mile or more.

[b] ( ) indicates existing.

Table 8.0.1-3 (Continued)

PORT	Pipeline Terminus	Total Pipeline Mileage	New Utility Corridor Mileage[a]	Pipeline Construction Mileage in Urbanized Areas	Pipeline Construction Mileage in Mountainous Areas	Major River Crossings	New Pipeline Construction Mileage in Parks, National Forest, Wildlife Refuges, Indian Reservations
Camp Pendleton, California	Midland, Texas	210+ (797)	120	0	10	2+(4)	16
Buena Vista, Guatemala	San Francisco del Mar, Guatemala	227	227	0	100	4	0

8.1 NO ACTION/DELAYED ACTION/TRANSPORT ENTIRELY BY TANKER ALTERNATIVES

8.1.1 No-action alternative

The no-action alternative considers that no new Long Beach Port terminal facilities and no crude oil pipeline construction to Midland, as proposed by the applicant, would be constructed. Therefore, under the no-action alternative, the primary available means for placing the bulk of North Slope crude oil, which would be surplus to West Coast needs, into domestic markets east of the Rocky Mountains would consist of utilizing the Jones Act fleet existing at that time. Fleet routings would be from Port Valdez, Alaska, to the U.S. Gulf of Mexico coast, where the North Slope crude oil could be absorbed, possibly backing out some foreign crude oil.

Should Prudhoe Bay crude oil not be shipped to the midwestern, southern, or eastern states, which are heavily dependent on foreign crude oil imports, reduced production on the North Slope is a possibility. On the other hand, neither the proposed project nor any of its viable alternatives would be required if it were decided to conserve North Slope oil by reducing production to a level equal to or below West Coast demand. Reduced production of this oil would have severe economic inpacts on the state of Alaska where state budget plans beginning in 1978 are being shaped by anticipated oil royalties from full production. Reduced production would likewise affect recovery of the large sums of capital invested in the Trans-Alaska pipeline by the various oil companies and their creditors. It is unlikely that a decision not to fully produce the Prudhoe Bay crude would be made at this time. Such a step would almost certainly require Federal financial allocations for oil companies and their creditors who are deeply committed financially to the development and marketing of Prudhoe Bay crude oil, as is the state of Alaska. The Trans-Alaska Pipeline Act in effect made the decision for full production of Prudhoe Bay crude oil.

Under the no-action alternative, transportation problems involved with distribution of Prudhoe Bay crude oil for domestic use could increase the possibility that this oil might be traded on the world market, perhaps to Japan or Canada. This would allow the import of an equivalent amount of foreign-produced oil which could be landed more cost-effectively (or with less adverse environmental impact) on the East or Gulf of Mexico coasts. However, this may increase the number of tanker trips to these ports.

The Trans-Alaska Pipeline Act (P.L93-153) states:

> "... before any crude oil subject to this section may be exported under the limitations and licensing requirements and penalty and enforcement provisions of the Export Administration Act of 1969, the President must make and publish an express finding that such exports will not diminish the total quantity or quality of petroleum available to the United States, and are in the national interest and are in accord with the provisions of the Export Administration Act of 1969:
>
> Provided, That the President shall submit reports to the Congress containing findings made under this section, and after the date of receipt of such report Congress shall have a period of sixty calendar days, thirty days of which Congress must have been in session, to consider whether exports under the terms of this section are in the national interest. If the Congress within this time period passes a concurrent resolution of disapproval stating disagreement with the President's finding concerning the national interest, further exports made pursuant to the aforementioned Presidential findings shall cease."

The preceding passage would apply to exports to any foreign counties, such as Japan. However, exchanges of oil with adjacent foreign states (Canada, Mexico) or temporary exports which reenter the United States for convenience or increased efficiency of transportation, are permitted under the Act without such approval and review by the President and Congress.

The sale or exchange of North Slope crude oil would still require tanker operations in the Valdez, Prince William Sound, and Gulf of Alaska areas. Impacts on air, water, and biological resources discussed in Chapters 3 and 5 of the FES for these areas would be similar under this alternative. Additional impacts on coastal environments would occur around a port area on Canada's west coast in the case of a Canadian trade (see Sections 8.2.1 and 8.2.2 for possible impacts) or in a Japanese port area (and possibly a U.S.

east coast area) in the case of a sale or trade with Japan. All impacts described in this document resulting from port construction and operation at Long Beach or construction and operation of a pipeline to Midland would not occur under this alternative. Such construction impacts would also be avoided in foreign (and possibly domestic) port areas where existing facilities are adequate to handle increased volumes of oil.

8.1.2 Delayed action

A decision to delay the implementation of the proposed project or any of its viable alternatives would tend to induce one or a combination of the following consequences:

The applicant has a combination of options for shipping surplus West Coast crude oil to markets east of the Rocky Mountains. These options include utilizing existing railroad tank cars and conversion of existing product lines as well as shipment via tanker to Gulf Coast ports. Shipment would be either around Cape Horn or through the Panama Canal, with or without lightering to smaller tankers.

Tankers in the 60,000 to 120,000 DWT ranges could fully utilize existing berthing facilities in the Los Angeles/Long Beach Harbor complex to bring in a portion of the Alaskan Prudhoe Bay production. Some ships would be partially lightered and continue to San Francisco or some might go to San Francisco directly. It is assumed that all channels leading to existing crude oil wharves would be dredged to a 45-foot depth before 1980 under normal maintenance. Existing terminal facilities would be encouraged to expand under the conditions of delayed action. Further, the crude oil surplus would encourage the existing 13 refineries in the Los Angeles area and also the petrochemical industries to expand, requiring increased tank storage facilities in the harbor area and adjacent to the refineries.

Assuming large tankers would be dedicated to carrying Alaskan oil to Panama or around Cape Horn, there would be more numerous tanker trips to Los Angeles than expected from the project as proposed. Possibilities for degradation of water quality from oil spills in the Port of Long Beach area would be greater. Significant growth in crude oil usage, however, is not expected because expansion of facilities would require permits from agencies charged with implementing air quality planning in this nonattainment area. The projected tanker activity would cause additional air pollutants (primarily SO_2 and NO) to be carried inland, adding to existing air quality problems in the basin. Full usage and possible expansion of storage facilities within the basin would further aggravate air quality problems.

Although no major new channel dredging would be required, normal maintenance dredging of existing harbor channels would continue. Land disposal of dredge spoil, including the possible expansion of existing landfills in the harbor, could add pollutants to the harbor waters through surface runoff. Submarine disposal of the dredging materials could affect the water column through the release of pollutants and turbidity. Temporary impairment of harbor water quality could result from silt runoff during construction of expanded terminal facilities, pipelines, and tank storage facilities in the harbor area during construction of pipelines to the inland refineries.

8.1.3 Transport entirely by tanker

8.1.3.1 Shipment around Cape Horn to the Gulf Coast

The largest vessels currently being built in U.S. shipyards are in the range of 200,000 to 390,000 DWT. However, the capacity for the construction of vessels of this size is limited. In this alternative it was assumed that U.S. flag carriers of 220,000 DWT would be utilized in the marine movement from Valdez to the Gulf Coast. At present, no 220,000 to 390,000 DWT tankers exist for the Jones Act fleet; however, 220,000 DWT tankers will be available during 1977.

Use of larger vessels would result in fewer tankers and in less loading and unloading at West Coast terminals. To the extent that spillage increases with the number of trips involved and that most chronic oil spills are associated with loading and unloading operations, the use of the larger vessels would perhaps give a slightly improved level of environmental impact by reducing exposure to such risks. However, the weather and rough water associated with the passage around Cape Horn is substantially more hazardous than the weather conditions which prevail between Alaska and California, and to this extent, environmental debits accrue to the Sea Leg around Cape Horn in terms of risk of major spill. Furthermore, upon arrival on the Gulf Coast, no facility currently exists for accommodating vessels of the 220,000 DWT class. Two U.S. deepwater port facility projects offshore of the Gulf Coast, Sea Dock and Loop, have been approved. However, the firms involved in these projects have not yet accepted the stipulations by the U.S. Department of Transportation. While not yet under construction, the facilities to handle 220,000 DWT tankers might be available by the early 1980s. At the present time, foreign flag tankers of this size are delivering their oil to Caribbean transshipment terminals such as Freeport at Curacao, West Indies, for subsequent transfer to smaller vessels which can be accommodated in U.S. Gulf of Mexico coastal ports. Controlling depths along the Gulf Coast vary from 35 to 45 feet. Transshipment would require double handling of the oil, creating additional opportunities for chronic oil spills with accruing environmental impacts.

The total round-trip distance from Valdez to the Gulf Coast via Cape Horn is approximately 31,000 nautical miles. During such a voyage, a 220,000 DWT (or largest tanker available that could be loaded at Valdez) tanker would consume about 90,000 barrels of bunker fuel, or about 0.065 barrels of bunker fuel per barrel of crude oil delivered. This is approximately four times the amount of energy which would be consumed in a marine haul from Valdez to southern California with subsequent pipeline movement to the interior of the United States.

8.1.3.2 Shipment through the Panama Canal to U.S. Gulf of Mexico coast

Shipment of crude through the Panama Canal has received and continues to receive serious attention from owners of Alaska North Slope crude.

The most critical question about the feasibility of the Panama Canal route for the transport of the West Coast crude-oil surplus is that of tanker availability. Also of great importance are the treaty negotiations now going on between the United States and the Republic of Panama. These negotiations could affect the future security and economy of using the Panama Canal as a crude transit point.

The Maritime Administration, in a study commissioned by the Federal Energy Administration, has determined that the existing and anticipated Jones Act fleet would be adequate to handle the full West Coast surplus should the Panama Canal route and lightering be used. Lightering would allow 80,000 to 250,000 DWT tankers to be used from Valdez to Panama and off-loaded at the Panama Canal to the 65,000 DWT tankers able to transit the Canal and off-load in Gulf Coast ports.

The Federal Energy Administration staff has conducted a brief analysis which determined the capacity of the Panama Canal for West Coast surplus of Alaskan crude oil to be 500,000 bbl/d (Federal Energy Administration, 1976).

The present Panama Canal capacity is limited to 34 ocean going vessels daily with approximately 20 hours Canal Zone waters time, including a transit time of about 10 hours. During fiscal year (FY) 1976, 12,280 ocean going vessels transited for a daily average of 33.6 trips. The daily average was approximately 34.5 vessels for the three months of May through July, 1976. In FY 1975, the daily average was 37.8 ocean going vessels. Of the total Panama Canal traffic, tanker transits during FY 1976 totalled 1,610 vessels or approximately 13 percent of the total ocean going transits. The crude oil tonnage passing through the Canal in FY 1976 was 11.9 million long tons.

By adding one additional lockage crew at each Panama Canal station and/or working present crews on an overtime basis, Canal capacity can be increased to 38 vessels daily. This increase can be accomplished on short notice. To increase Canal capacity beyond 38 vessels daily, additional requirements would include the purchase of tugboats as well as adding lockage crews. By increasing these elements and purchasing additional locomotives, Canal capacity can be increased to more than 50 vessels daily.

The physical limitations for vessels transiting the Panama Canal are a maximum length of 960 feet, beam of 106 feet, and drafts of 37 to 39.5 feet. The canal can accommodate laden vessels of approximately 65,000 DWT to 89,000 DWT, depending on the vessel's particular dimensions.

With regard to the feasibility of lightering operations, the Pacific anchorage is an unprotected open anchorage with no moorings. A 60-foot draft vessel could be accommodated about 5 miles offshore. Plans for a deep water mooring port for lightering operations are being developed by private companies and the Republic of Panama.

Transit of 500,000 bbl/d of crude oil would require an average of one to two Panama Canal transits per day of fully loaded 65,000 DWT vessels. The above information provided by the Panama Canal Company, which also expressed its desire to increase ability of the Canal to handle world traffic, indicates that the Canal could handle the tanker traffic necessary to move the Alaskan surplus. The company indicated further that lightering operations from large tankers of the Valdez-to-Panama route to tankers able to transit the Canal are feasible.

The environmental implications of this alternative are not greatly different from those associated with the Cape Horn alternative discussed in Section 8.1.3.1. The major differences are that passage through the Panama Canal eliminates the dangers of stormy Cape Horn waters while the Cape route eliminates lightering at the Canal. Lightering results in substantial

emissions of hydrocarbon vapors. The use of smaller vessels (65,000 DWT or less) for the entire route increases the total number of loading and unloading operations necessary to transport this oil. Also, utilization of smaller tankers results in increasing the total tanker traffic along the West Coast with the corresponding implications of greater risks of collision. If larger vessels were used on the Pacific side of the movement, additional handling would be necessary to transfer the oil from the larger vessels to the smaller vessels for the Panama Canal passage. Chronic spillage would be greater.

The total round-trip distance from Valdez through the Panama Canal to St. James, Louisiana is approximately 17,000 nautical miles. During the round-trip portion from Valdez to the Canal, a 165,000 DWT tanker would consume approximately 27,950 barrels of bunker fuel. During the trip portion from the Canal to Louisiana, assuming approximately 2.5 65,000 DWT tankers to transport the cargo of the 165,000 DWT tanker, 15,840 barrels of bunker fuel would be consumed. This is approximately 0.037 barrles of bunker fuel per barrel of crude oil delivered, or about one-half that demanded by delivery to the Gulf Coast via a route around Cape Horn.

The Department of Transportation estimates that the cost of delivering crude to Gulf ports via the Cape Horn route would be $3.01 per barrel as compared to the estimated $2.14 per barrel if the oil were transported through the Panama Canal with lightering operations.

8.1.4 Transport by tanker with use of existing Navy pipelines, Panama Canal

There are four existing pipelines across the Isthmus of Panama which were constructed by the U.S. Navy in the early 1940s. Two are currently in use and two are not. The two lines in use include a 20-inch line with a pumping capacity of 3,400 barrels per hour and a 10-inch JP5 line with a pumping capacity of 1,300 barrels per hour. The two lines not in use are packed with water. They are a 20-inch line last used for diesel, with a pumping

capacity of 3,000 barrels per hour, and a 10-inch line which has never been used and needs additional linkage lines. The system was designed for Atlantic-to-Pacific pumping, and the capacity from Pacific to Atlantic is less than the rated pumping capacity.

Pipeline terminals are at Rodman piers on the Pacific and Dock 16 on the Atlantic. Vessels using the facilities are subject to physical limitations similar to those transiting the Panama Canal. The pipelines will be out of use in 1977 and 1978 during the Panama Canal widening project. (Widening the Canal will not increase the existing 65,000 DWT tanker limitation of the Canal.)

Utilizing these pipelines for commercial activity would require revision of the 1936 U.S. Treaty with Panama (U.S. Treaty Series 945).

8.2 PORTS OF ENTRY AND PIPELINE ROUTING ALTERNATIVES

The following discussion of the alternative ports and pipeline routes is derived mainly from the Environmental Impact Report (Arthur D. Little, 1976) for the Port of Long Beach, the Environmental Impact Assessment Study (Williams Brothers, 1976) for SOHIO, the West Coast Deepwater Port Facilities Study (U.S. Army Corps of Engineers, 1973), the Environmental Impact Study-SOHIO Sea Leg for the U.S. Army Corps of Engineers (Tetra Tech, 1976), North Slope Crude, Where to? -- How? (Federal Energy Administration, 1976), Environmental Assessment of Avila Beach and Oso Flaco (Engineering-Science, 1976) for SOHIO, Seeking Environmental Compatibility (Mitre Corp., 1977) for EPA, and reference to the National Atlas (U.S. Geologic Survey, 1970). Utilizing any of the following ports of entry would have no discernible effects on the impacts at Valdez or Prince William Sound.

8.2.1 Kitimat, British Columbia, Canada (port), to Edmonton, Alberta, Canada (pipeline terminal)

See Figure 8.2.1-1 for geographic location of Port of Kitimat and pipeline route to Edmonton.

8.2.1.1 Port of Kitimat, British Columbia, Canada

The port of Kitimat is situated at the head of the Douglas Channel, a fjord 80 miles long that reaches into the Coast Mountains off Hecate Straits. Douglas Channel, roughly 2.3 miles wide, has extremely deep waters along its entire length. The area is capable of accommodating two tanker berths initially, each capable of receiving up to 300,000 DWT tankers. Additional berthing space could be added for future expansion. Dredging would not be necessary, and floating docks could be utilized. Onshore facilities would include storage tanks capable of storing a 10-day pipeline throughput (3 million barrels) with a future expansion to 5 million barrels.

A railroad, highway, electrical transmission line, and a gas pipeline traverse the valley to the town of Kitimat, approximately 18 miles away. Petroleum-related development at Kitimat is possible since adequate land and utilities are available, but the distances to an acceptable market make major development unlikely.

Maritime environment

Entrance to Kitimat and Douglas Channel is difficult. The approach involves close navigation of 210 miles from Dixon Entrance through Hecate Straits into Caamano Sound and then into Douglas Channel. Cliffs, reefs, and rocks extend many miles into the sound and straits, but the channels are well mapped. However, the portal is difficult to navigate even by radar, and there are extremely strong currents in the area. Visibility is less than 5 miles for 8 to 13 percent of the time annually, and daily tidal ranges vary

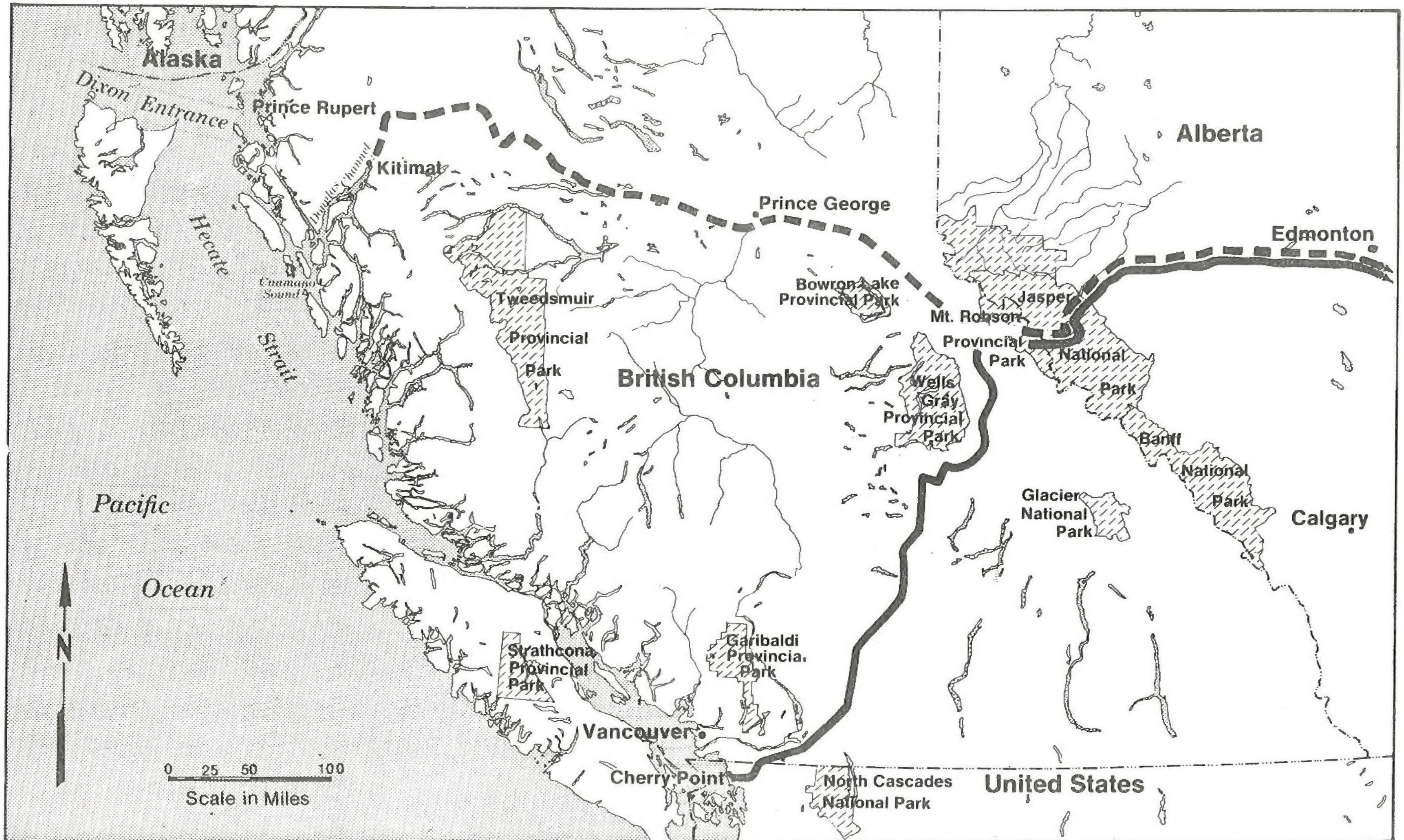


Figure 8.2.1-1 Port and Pipeline Alternatives
Kitimat-Edmonton (proposed)
Cherry Point-Edmonton (existing)

from 25 feet to 14 feet. In addition it should be noted that for the majority of Caamano Sound, the surveys were made in 1923, using lead line sound, and this work is not considered adequate by modern survey standards.

The ship traffic volume is low (less than 700 ships per year), and there is an almost complete lack of large ship navigational aids on the approaches. No pilots are closer than Prince Rupert to the north on Hecate Straits. Overall, the Kitimat Harbor approach would present moderately hazardous navigation conditions for oil tankers.

Oceanic biology

Coastal waters in the area are highly productive, supporting major fisheries in Caamano Sound, Dixon Entrance, and Hecate Straits. The fisheries include halibut, herring, ling cod, northern anchovy, English sole, Pacific cod, sculpin, starry flounder, and red snapper. Anadromous fish are important and include five species of salmon and steelhead trout. Marine mammals, such as the hair seal, fur seal, sea lion, and sea otter, frequent the sounds and straits. Major or chronic oil spills, would have very severe impacts on these highly productive, diverse marine populations. A commercial shellfish resource exists in the northern Queen Charlotte Islands which would be especially susceptible to oil pollution.

Coastal biology

The steep walls of Douglas Channel offer marginal coastal habitat compared to the estuaries and protected stretches in the vicinity of Prince Rupert farther north along Hecate Straits. One sensitive area of importance along the tanker route is the small Kitimat River estuary at the head of Douglas Channel. The area, within the Pacific flyway, forms a part of the northern breeding grounds for many species of migratory ducks and geese. Common waterfowl and shorebirds in the area include cormorants, grebes, puffins, guillemonts, gulls, sandpipers, sanderlings, killdeer, plovers, and anks

(80,000 to 90,000 breeding pairs in 1971). There is also a population of the Endangered American peregrine falcon in this vicinity. An oil spill could impact hundreds of miles of shoreline. The complex geography and strong currents would hinder and possibly prevent the successful deployment of equipment for oil spill containment and removal.

Air quality

Kitimat has significant air quality problems. Inversion conditions are common, with occasional poor ventilation. Drainage winds result in the poorest ventilation during the winter; a ground-level inversion is common in the morning. The existing industries, a pulp mill and an Alcan aluminum plant, produce moderately high sulfur oxide and fluoride emissions. The project would add somewhat to the sulfur oxides and introduce major new quantities of hydrocarbons and nitrogen oxides. Unless the facility were restricted to tankers with inert gas systems and at least 20 percent segregated ballast, a severe oxidant problem could result. Some oxidant would result from the storage tanks.

Geology

Kitimat is underlain by old metamorphic rock. Because of its distance from the nearest earthquake epicenter, any earthquake effect is likely to be minor. The underlying rock shows no evidence of recent seismic activity and very little faulting. The thickness or stability of unconsolidated overburden sediments in the waterfront area is not known. A more detailed geologic survey of the waterfront area should be conducted as part of facilities planning.

Terrestrial biology

Coniferous forest with dense underbrush lines the steep coast of Douglas Channel and the margins of Kitimat Valley. The understory is diverse and provides habitat for a wide variety of wildlife. Since cleared land is available for the project, little direct disturbance would result from the tank farm terminal facility.

Land use

The two major industrial plants, a pulp mill and an Alcan aluminum plant, occupy sites in the lower valley. The city of Kitimat, population 13,000, is located 18 miles up the valley and is economically dependent on the two major industrial plants. There is a 25-boat fishing fleet and about 1,600 small craft berths at Kitimat. A transshipment facility would pose little conflict with existing land uses.

Visual and recreational resources. Impacts of a terminal are expected to be minimal due to major existing industrial plants and minor small boat and fishing activity. The oil spill hazard would be the most significant problem.

Socioeconomics

Kitimat has already been designated as a regional center for maritime and industrial development in British Columbia. The small Indian reservation and fishing village has grown quickly in the past decade. The labor force is well suited to a transshipment facility. If large port construction were to take place, community services such as schools and hospitals might be strained. There also could be housing shortages and other imbalances in the local economy if large numbers of laborers were imported into the area.

8.2.1.2 Kitimat, B.C., Canada, to Edmonton, Alberta, Canada, pipeline

A group of U.S. and Canadian refiners and pipeline companies propose a pipeline from Kitimat, British Columbia, to Edmonton, Alberta, where it will connect to the existing Interprovincial-Lakehead system and the Trans-Mountain pipeline. The Interprovincial-Lakehead line is connected to refineries in Montana, the Dakotas, and Minnesota, and also serves the Chicago, Detroit, and other major Great Lakes refining and population centers. The distance from Kitimat to Chicago is approximately 2,300 miles.

The pipeline, as proposed, would be approximately 780 miles in length. From Kitimat to Tete Jaune Cache west of Jasper National Park, the line parallels an existing corridor containing (in most areas) a highway, railroad, natural gas pipeline, and electric transmission line. At Tete Jaune Cache, the line would meet the Trans-Mountain crude oil pipeline which it follows for about 300 miles to Edmonton.

The proposed line would traverse mountainous terrain for the majority of its length from Kitimat until it enters the Canadian prairies of Alberta. The Coastal Mountains and the Canadian Rocky Mountains are the primary ranges crossed. The provincial boundary between British Columbia and Alberta is the Continental Divide along the crest of the Rocky Mountains.

Terrestrial biology

All segments of the proposed route are dominated by relatively undisturbed forest settings, although the characteristics vary with distance from the coast and elevation. Near the coast, rain forest of spruce, cedar, and hemlock occurs; montane forest exists in the area of Talkwa Pass and the Continental Divide. The mountainous lower elevations inland are dominated by northern subalpine forest. The northern plateau of Alberta is predominantly spruce and fir forest transitioning to wheat grass prairie to the south.

Common construction practices call for vegetation to be cleared along a 75- to 150-foot construction corridor. Erosion of steep slopes and disruption of vegetation habitat and wildlife would result from movement of equipment and materials and from other construction activities. Streams would be highly sensitive to construction impacts both directly from the construction activity in the channels, and indirectly from the siltation generated by erosion within the pipeline construction corridor. There are a total of 14 major river crossings where impacts would be high: Kitimat, Skeena, Zymontz, Telkwa Bulkey, Morice, Endako, Wechako, Chilako, Salmon, Fraser (twice), Athabasca, and McLeod rivers. Following construction, impacts will continue since it can be estimated that roughly 50 feet of the corridor will be maintained clear of vegetation to permit surveillance and line maintenance. The periodic passage of vehicles and persons along the line would result in further disturbance.

Land use

Utilization of existing transportation corridors would permit the proposed pipeline route to bypass both the urban and the limited agricultural land uses occurring near the Kitimat area.

The 575-mile link from Kitimat to Hinton through mountainous areas is dominated by ungrazed forest land. Utilization of an existing transportation corridor containing a gas pipeline for a portion of the route and a crude oil pipeline for much of the remainder would be expected to reduce the potential impacts an all-new corridor would have on the forested areas. However, Mt. Robson Provincial Park and the adjacent Jasper National Park would be crossed for 90 miles within this link. These park areas are considered to be highly sensitive to impacts. The fact that an existing crude oil line would be paralleled through this sector could be expected to reduce the potential impacts.

As the route continues from Hinton to Edmonton, the high northern plateau of Alberta is entered. Forest lands extend to near Edmonton where the transition is made to open prairie. The last 60-mile link of the route encounters increasing cultivation and human activities as the line enters Edmonton. Disruptions could be expected to occur from the cutting of streets, movement of equipment and materials, and the proximity of construction activity to the urbanized area. An existing crude oil pipeline right-of-way would be followed through this segment.

Visual and recreational resources. The pipeline route would avoid primitive areas thereby avoiding impacts on pristine environments with high scenic and recreational values. However, the proposed corridor would traverse a significant tourism area along Provincial Highway 16 with numerous fishing and boating lakes and streams, and developed campgrounds. It is likely that the swath cleared through the forested mountain environment by a pipeline would be highly visible to tourists using these recreation resources and this scenic highway. The pipeline would also traverse Jasper National Park and Mt. Robson Provincial Park. Even if the proposed pipeline only widened an already existing utility corridor through these parks, it would be an incompatible intrusion that violated the scenic and natural values which the parks were established to preserve. Until pipeline hydraulics are engineered, pump station sites cannot be projected.

Socioeconomics

Socioeconomic impacts along the pipeline route would include strain on community services such as hospitals and schools and police. There could also be housing shortages and other imbalances in the small towns along the route caused by an influx of pipeline construction workers for a relatively short time.

8.2.2 Cherry Point, Washington, to Edmonton, Alberta

There is a proposal by the Trans-Mountain Pipeline Company to alternate eastward and westward crude oil shipments with its west Canada line using ARCO's Cherry Point Terminal for tanker off-loading.

8.2.2.1 Port of Cherry Point

Puget Sound is located at the northwestern corner of Washington state. Climatic, oceanographic, and ecological conditions of the protected bays and fjords of the sound and coastal estuaries differ significantly from conditions on the outer Washington coast. The biological diversity and productivity and the magnitude of the Puget Sound basin are unique. The Puget Sound system, carved by glaciers, is characterized by numerous channels, sounds, inlets, protected bays, and fjords. The channels of the sound are deep (maximum depth of 930 feet) with a minimum controlling depth for marine traffic of 200 feet. The area includes literally hundreds of shallow estuaries which drain portions of the Olympic Mountains and Cascade Range and surrounding low hills. The Strait of Juan de Fuca provides the main connection between the sound and the Pacific Ocean to the west, with additional access through the Georgia Strait from the north. The Strait of Juan de Fuca is approximately 80 miles long, more than 12 miles wide, and in excess of 190 feet deep in places.

Cherry Point lies at the south end of the Georgia Strait, approximately 10 miles from the Canadian border and 140 miles from the Pacific Ocean. Two oil refineries, Atlantic Richfield Oil Company (ARCO) and Mobil Oil Company, have a combined processing capacity of 175,000 bbl/d. The firms have berthing facilities located in 65-foot and 42-foot water depths. Cherry Point is currently served by the Trans-Mountain pipeline from Canada. In the past, the refinery crude oil requirements were supplied by tanker and a shoreside pipeline.

Use of the site would entail construction of a deepwater berth for three tankers of the 165,000 DWT class. However, smaller vessels would have to be used, since under Washington state law, tankers larger than 125,000 DWT are prohibited from entering Puget Sound. This limitation is now under judicial appeal to the U.S. Supreme Court. If the Trans-Mountain reversal pipeline alternative were implemented, little construction would be required for service at Cherry Point. Pipeline construction would be limited to several pump stations that would be required on the Puget Sound side of the Canadian Rockies and to new surge tanks.

Maritime environment

Ship transit from the Pacific Ocean to Cherry Point would involve passage through the Strait of Juan de Fuca into Puget Sound and then through the narrow Rosario Strait and the southern end of the Strait of Georgia. The route involves a number of course changes and intersects other maritime traffic. The accident rate of 5.3 casualties per 1,000 tanker trips for Puget Sound is high, second only to the San Francisco area for all West Coast ports. The high rate reflects adverse weather conditions, a long ocean-to-port navigation distance, and a relatively high volume of ship traffic of 3,180 ships per year.

Most waters of Puget Sound exhibit ebb and flood currents of approximately 1 knot. Narrow passages such as Rosario Strait exhibit turbulent rips and whirlpools and ebb and flood currents of 5 to 7 knots. The tidal range at Cherry Point is 9 feet, and currents are weak and variable. Winds at the Pacific entrance to the Strait of Juan de Fuca are strongest from October through March, blowing mostly out of the southeast through southwest. Gales blow on the average of four to six days per month. During the summer, winds blow mainly from the southwest through the northwest. Daytime winds range up to 15 knots, and calms are often the rule at night. Sea fog, the most common type in the Strait of Juan de Fuca, is at its worst from July through October. Visibilities drop to less than 0.75 miles on about 55 days

annually (USDI, 1975). A high offshore precipitation frequency contributes to visibility problems.

In general, the maritime environment of Cherry Point is considered moderately hazardous.

Oceanic biology

The ocean waters of the north Pacific Coast and most areas in Puget Sound are in a relatively undisturbed and pristine condition. Upwelling currents and multiple coastal rivers bring nutrients to the surface waters. Rocky shorelines and reefs provide extensive areas for brown kelp and red and green algae. These beds serve as food and shelter for a diversity of marine invertebrates and fish.

Offshore fisheries, commercial and sport, include salmon, ling cod, rockfish, and Pacific Ocean perch. Other commercial fisheries include Dungeness crab, several shrimp species, and razor clams.

Marine mammals are found along the entire stretch of the north Pacific coast. The relatively undisturbed state of these waters provides a refuge for a large number of species. Whales in the area include sperm, pygmy sperm, Pacific killer, pilot, gray, humpback, finback, Baird, and Pacific beaked whales. Other pelagic mammals include long snout, right whale, Pacific whitesided dolphin, and the Dall's porpoise. Pinnipeds and sea otters utilize the isolated, rocky oceanic islands as well as the coastal caves and beaches along the coast.

The impacts of oil spills in offshore northwest waters are potentially great. Spills in the open ocean are nearly impossible to contain, and the cool, oceanic waters would result in slow biodegradation and weathering of spilled oil. The severity of crude oil impacts on marine life would depend in part on the location of the spill area, the biota in the area, the

dispersion and amount of weathering, and the season. In general, the oceanic biology is diverse and sensitive, and potential impacts are severe.

Coastal biology

Puget Sound in the vicinity of Cherry Point is an exceptionally rich biotic environment. Ecological conditions vary from pristine salt marsh estuaries, such as Nisqually Flats, to near outer-coast conditions, such as the Tacoma Narrows. Marine algae, kelp, and marine spermatophytes, such as eelgrass and pickleweed, are distributed throughout the archipelago. The north Puget Sound subbasin is strongly influenced by freshwater inflow from the Samish, Noodsack, and Skagit river systems. The delta and estuarine areas of these rivers comprise some of the most important waterfowl habitat in the state. The waterfowl and seabirds in the area include loons, grebes, cormorants, gulls, terns, alcids, seaducks, puffins, guillemots, and oyster catchers. Two Rare or Endangered species, the whistling swan and the trumpeter swan, inhabit Noodsack Estuary and DeBay Slough, respectively. Harbor seals are common on the islands.

Fish and fishery resources of the region are great. The area serves as a spawning area for surfsmelt and herring, nursery and feeding area for salmon, and a migration corridor for anadromous species such as salmon, steelhead, and smelt. Commercial fisheries harvest pink and sockeye salmon, herring, shrimp, crab, scallops, and a number of bottom fish. Mariculture is becoming an important industry, with a multimillion-dollar aquaculture project in Lummi Bay and several commercial clam farms and oyster-culture areas.

Wildlife refuge areas in the north Puget Sound include Matia Island National Wildlife Refuge, Jones Island National Wildlife Refuge, and Lake Terrell State Wildlife Recreation Area. Biological study areas are also at Friday Harbor on San Juan Island and at Point Roberts.

Any oil released on the approach to Cherry Point or at the terminal would quickly be driven into coastal areas. Spills could impact entire populations of many species. Hundreds of miles of coastline could be adversely affected. Mitigating measures, such as oil spill contingency plans and containment and removal equipment, would probably be ineffective because of the numerous channels and strong currents. The cool waters result in retarded biodegradation and weathering of crude oil.

Air quality

The Ferndale-Cherry Point area frequently experiences moderate to strong ventilating winds. Fuel consumption for aluminum production in Ferndale has resulted in large emissions of sulfur oxides, on the order of 1,000 tons per year, and particulate emissions are slightly in excess of that. Substantial amounts of hydrocarbons are produced by the refineries at Cherry Point. There is marginal information that oxidant levels approach but do not exceed the level in the Federal oxidant standards (0.08 ppm). Short-term sulfur dioxide standards are exceeded a few times each year.

Emissions from older tankers with insufficient segregated ballast would be likely to result in annual violation of the Federal oxidant standards. With mitigating measures similar to those committed at Long Beach, the adverse impact would be possibly the same, but probably less at Ferndale-Cherry Point than at Long Beach. The adverse impact from sulfur dioxide with and without mitigating measures would be the same or worse. There is a somewhat lower population density adjacent to the proposed terminal which would be subject to stack gas emission; adverse impacts upon aesthetics and recreational resources would be greater.

Geology

Cherry Point is in a seismic area, but with no important surface faults in the vicinity. The area is located approximately 40 miles west and slightly north of two historic epicenters of earthquakes with intensities of Mercalli VII, and 160 miles west of a large earthquake epicenter (Mercalli IX) in eastern Washington. Maximum bedrock acceleration that could be expected in the area from the 50-year earthquake is estimated at only 0.1 g. Information was not available with respect to the liquefaction potential of the sediments at Cherry Point.

Terrestrial biology

The Puget Sound region has a wide variety of terrestrial life, including wildlife of both aesthetic and game value. Except for the refinery facilities, the Cherry Point area has a relatively nonintensive land-use quality, composed of minor woodland and riparian zones interspersed with cultivated fields. The habitat is considered moderately disturbed and is not considered rare or unique.

Land use

Industrial and refinery facilities dominate the land use in the Cherry Point area. In the surrounding area, an extensive patchwork of small productive farms is found. The town of Ferndale, population 2,500, is roughly 2 miles distant. Land-use impacts from the alternative would be minor, since there is plentiful flat land and oil-related industry, and existing terminal facilities are already present.

Visual and recreational resources. Because of the dominant industrial nature of the Cherry Point-Ferndale area, the construction and operation of tanker berths and oil tankage would have minimal impacts on scenic and recreation resources. However, an oil spill from a tanker accident within Puget Sound would have severe impacts on recreation and visual resources such as the shoreline estuaries. The archipelago is highly scenic and Puget Sound is extensively used by fisherman and boaters. Cleanup of some of the highly scenic rocky shorelines in the archipelago would be especially difficult.

Socioeconomics

Ferndale, Cherry Point's nearest town, has an industrial economic base, including oil-related industries. Bellingham, population 40,000, is only 12 miles away. The industrial-worker infrastructure is already present, hence long-term impacts may be minimal. During construction of expanded berthing, tank farms, and pump stations, there may be moderate disruptions in community services, such as police, housing, and hospitals, from an influx of short-term construction workers.

8.2.2.2 Cherry Point, Washington, to Edmonton, Alberta, pipeline

The existing Trans-Mountain pipeline has a capacity for moving 420,000 barrels of crude oil per day westward from Edmonton, Alberta, to eight refineries in the Seattle area. However, only 180,000 bbl/d have been moving through the line: four plants in the Vancouver area are getting 120,000 bbl/d and two refineries in Washington are getting a combined 60,000 bbl/d. Canada is phasing out its crude exports to U.S. refiners, and the cutback results in greater surplus capacity in the pipeline.

The proposal is to alternate the flow in the pipeline so that 120,000 bbl/d reach Vancouver and 165,000 bbl/d reach Edmonton. Alternating the flow would take the line out of service for two days at a time. The

Interprovincial line has about 400,000 barrels of excess capacity east to Clearbrook, Minnesota, which would allow input from the Trans-Mountain system.

It is expected that large storage tanks would have to be built at both ends of the pipeline to keep the oil flowing at the daily rate.

The Trans-Mountain pipeline could be fully reversed at a later date if oil discoveries were made in Alaska and offshore California which greatly increased the current projections of a West Coast crude surplus in the early 1980s.

A new pump station at Cherry Point, Washington, and several as yet undetermined sites in British Columbia and Alberta, along with new valves, would be the only new construction. Depending on the specific sites, new pump stations in British Columbia and Alberta would have minimal to significant impacts on land use, vegetation, wildlife, and visual resources. Construction of the pump station with the short-term influx of construction workers would have short-term socioeconomic impacts on the community services of small towns near the sites.

8.2.3 Puget Sound, Washington, to Clearbrook, Minnesota

This alternative involves a port in Puget Sound and a new pipeline to Clearbrook, Minnesota. The two alternative ports considered are Cherry Point and Port Angeles. See Section 8.2.2.1 for discussions of Cherry Point and Puget Sound, and Figures 8.2.3.2-1A, 1B, and 1C for geographic location of alternative ports and pipeline route.

8.2.3.1 Port Angeles, Washington

Port Angeles Harbor is situated on the south shore of the Strait of Juan de Fuca at the entrance to Puget Sound. Ediz Hook, a narrow sandspit, extends into the strait, enclosing the harbor on two sides. The harbor is 2.7 nautical miles long and 1.4 miles wide at the entrance. The harbor is of sufficient size and depth to accommodate the largest ships without congestion and without major dredging. Passage to the harbor would require no tanker traffic through Puget Sound, and, therefore, under present state tanker regulations, is open to use by vessels over 125,000 DWT.

Port Angeles is located west of Puget Sound and has no direct overland access to the refineries and to major market centers. The infrastructure necessary to serve a major port is lacking in some regards. No tanker fuel bunkers exist. Extensive backup facilities would be required, but the terminal would not be an unusual cost item. A pipeline, probably constructed around the western and southern end of Puget Sound, would traverse 200 miles of difficult and environmentally sensitive areas in order to join the various northern corridor alternatives or to serve the Puget Sound area itself.

Maritime environment

The oceanographic and navigation conditions of the tanker route were characterized under the discussion of maritime environment of Cherry Point. The route would require passage through the Strait of Juan de Fuca, with close navigation for 80 miles. Average diurnal tidal range is 7.2 feet, and estimated extremes range up to 15 feet. Tidal current in the strait averages 1.6 knots, but is weak and insignificant in the harbor. The navigation hazards at Port Angeles are estimated to be moderate, since the long, difficult approach into the inner sound sites is avoided.

Coastal biology

The degree and diversity of the biota are less than in the inner sound. Within the harbor, the natural environment has a limited flora and fauna and no significant kelp beds. Shellfish are increasing in the harbor, but are not commercially important at present. Important habitats for anadromous fish, herring, and shellfish in the area include the Grey Wolf, Lyre, and Dungeness rivers, and Discovery and Sequim bays. Whales pass through the Strait of Juan de Fuca but are not found in the harbor.

Especially sensitive areas include the Olympic National Forest, 3 to 5 miles from the harbor; Dungeness National Wildlife Refuge, 12 miles to the east; and San Juan Marine Reserve, 30 miles to the northeast. Dungeness National Wildlife Refuge is one of the major waterfront areas of the state. It serves as a migratory bird refuge and as a habitat for harbor seals.

Harbor spills can be contained, provided that Ediz Hook is neither breached nor eroded by storms and oil spill containment equipment is quickly deployed. The major risk with a higher probability of occurrence than the foregoing is of a large spill outside the harbor in the Strait of Juan de Fuca. The spill could adversely impact the valuable island habitats of the San Juan Archipelago, the Dungeness National Wildlife Refuge, and waters and shores of the Strait of Juan de Fuca, including Olympic Peninsula and Vancouver Island, British Columbia.

Air quality

Port Angeles frequently experiences ventilating winds from the ocean and landward sides. Wind flows are channeled by the Olympic Mountains and Cascade Range. Industrial emissions, predominantly sulfur oxides and particulates from lumber and pump mills, have caused air quality problems under some weather conditions. Current abatement programs are reducing violations of the Federal and state sulfur dioxide standards. There is

little available data on levels of hydrocarbons, nitrogen oxides, and resultant oxidant, although areas within the sound regularly experience oxidant levels near or above the level in the Federal standard (0.08 ppm). Levels are probably higher during clear or partly cloudy weather with variable winds. Oxidant problems are due to growing emissions associated with population and petrochemical activities.

Emissions from older tankers with insufficient segregated ballast would pose a serious oxidant problem. With mitigating measures similar to those committed at Long Beach, the adverse impact would be possibly the same, but probably less at Port Angeles. The adverse impact from sulfur dioxide with, and without mitigating measures would be the same or worse. Port Angeles (17,000 population) presents a similar population density to that of Long Beach downwind from the proposed terminal; adverse impacts from stack emissions upon aesthetics and recreational resources would be greater than at Long Beach. There would be some general air quality benefits associated with the shorter tanker route from Alaska to Port Angeles.

Geology

Port Angeles is in a zone of relatively low seismic activity. The site is located 30 miles north of an epicenter of an earthquake of Mercalli intensity VII; 40 miles west of three epicenters of Mercalli VI; and 150 miles southwest of an epicenter of large earthquakes (Mercalli IX). Moderate bedrock acceleration is expected, estimated at only 0.1 g from the 50-year earthquake. Liquefaction and landslide potentials are unknown. Such information would be necessary to provide reasonable protection against seismic hazards for project structures.

Terrestrial biology

The terrestrial biology of the Port Angeles area is transitional between the exposed outer coast, the sheltered sound, and the steep Olympic Mountains to the south. Small zones of unique or unusual habitat occasionally dot the mosaic of Douglas fir forests, urban, and agricultural lands. A unique, dry environment, similar to that in eastern Washington, is found in the flatlands along the Dungeness Spit and occasionally in portions of the foothills. If the project utilizes only a small area of backup land for storage/surge facilities as proposed, then the rare environments might not be significantly affected. However, extensive ancillary development would lead to secondary impacts, possibly removing or otherwise adversely affecting some of the unusual upland habitats.

Land use

Port Angeles, population 17,000, has an economy based on maritime trade of forest products, some agriculture, and a rapidly developing recreation and tourism industry. Land-use conflicts may arise from the intensification of the industrial component of the economy interfering with the recreational component. Oil-related development could possibly block public access to a small portion of the regional coastal resources.

Visual and recreational resources. Tourism is a major component of the economy of Port Angeles. The tanker berthing facilities and the terminal tankage would be a conspicuous industrial intrusion that, in terms of scale, is likely to visually dominate the port. An oil terminal facility is a different kind of industrial facility than the existing maritime timber products industry, which is regarded by many as a picturesque part of Port Angeles. An oil terminal at Port Angeles would adversely impact recreational boating and fishing resources. An oil spill from a tanker accident within the Strait of Juan de Fuca could wash ashore on Vancouver Island or the northern Olympic Peninsula which has a series of pocket

beaches amidst rocky headlands of high scenic quality and recreational value. The rocky headlands would be especially difficult for oil spill cleanup.

Socioeconomics

The industrial labor infrastructure is based primarily on forest products. Development of a major oil terminal would introduce new urban industrial employment opportunities into the largely nonurban north shore of Clallam County. Development of Port Angeles as an oil port would adversely affect the growing recreation tourism industry. An influx of construction workers to build the terminal berths and tank farm would place strain on community services including hospitals, schools, and police protection, as well as housing.

8.2.3.2 Puget Sound, Washington, to Clearbrook, Minnesota, pipeline

See Figure 8.2.3.2-1A, 1B, and 1C for geographic location of pipeline route.

The proposed routing from Puget Sound would serve either the Cherry Point or Port Angeles port of entry. From the industrialized area which dominates the Cherry Point environs, the proposed corridor turns due east through small but productive farm lands, and intersects the Burlington Northern Railroad at a point some 24 miles from Cherry Point. The line then follows the railroad right-of-way in a southerly direction for approximately 100 miles, through the communities of Sedro-Woolley, Arlington, Snohomish, and Bothell, passing in close proximity to Bridle Trails State Park, continuing through Bellevue, adjacent to Lake Washington, then crossing in a southeasterly direction to Renton, intercepting the Port Angeles alternative at a point approximately 7 miles above Enumclaw.

From Port Angeles, the alternative link would follow the Chicago, Milwaukee, St. Paul and Pacific Railroad right-of-way eastward to the community of

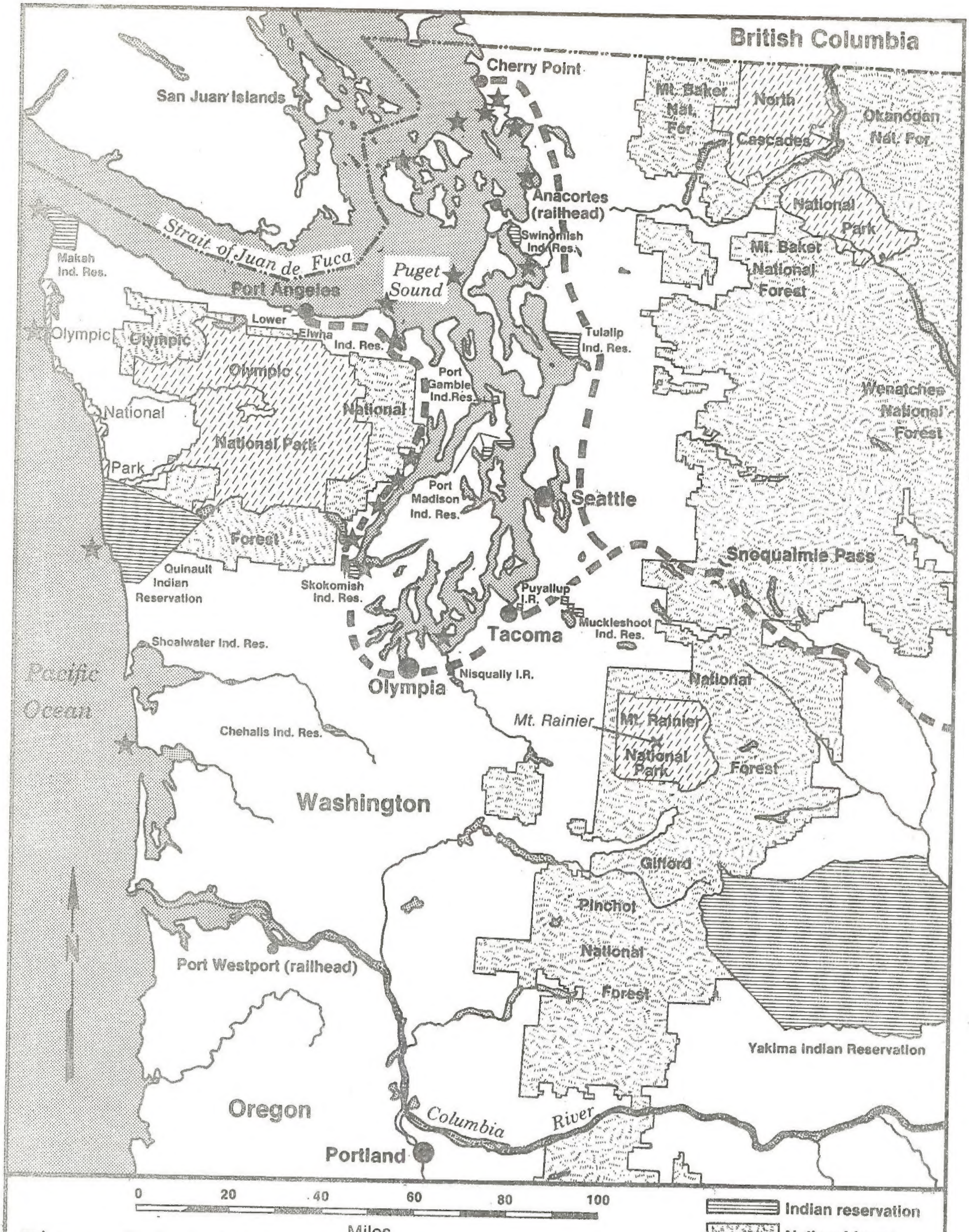


Figure 8.2.3.2-1A
Port and Pipeline Alternatives; Puget Sound, Washington, to Clearbrook, Minnesota

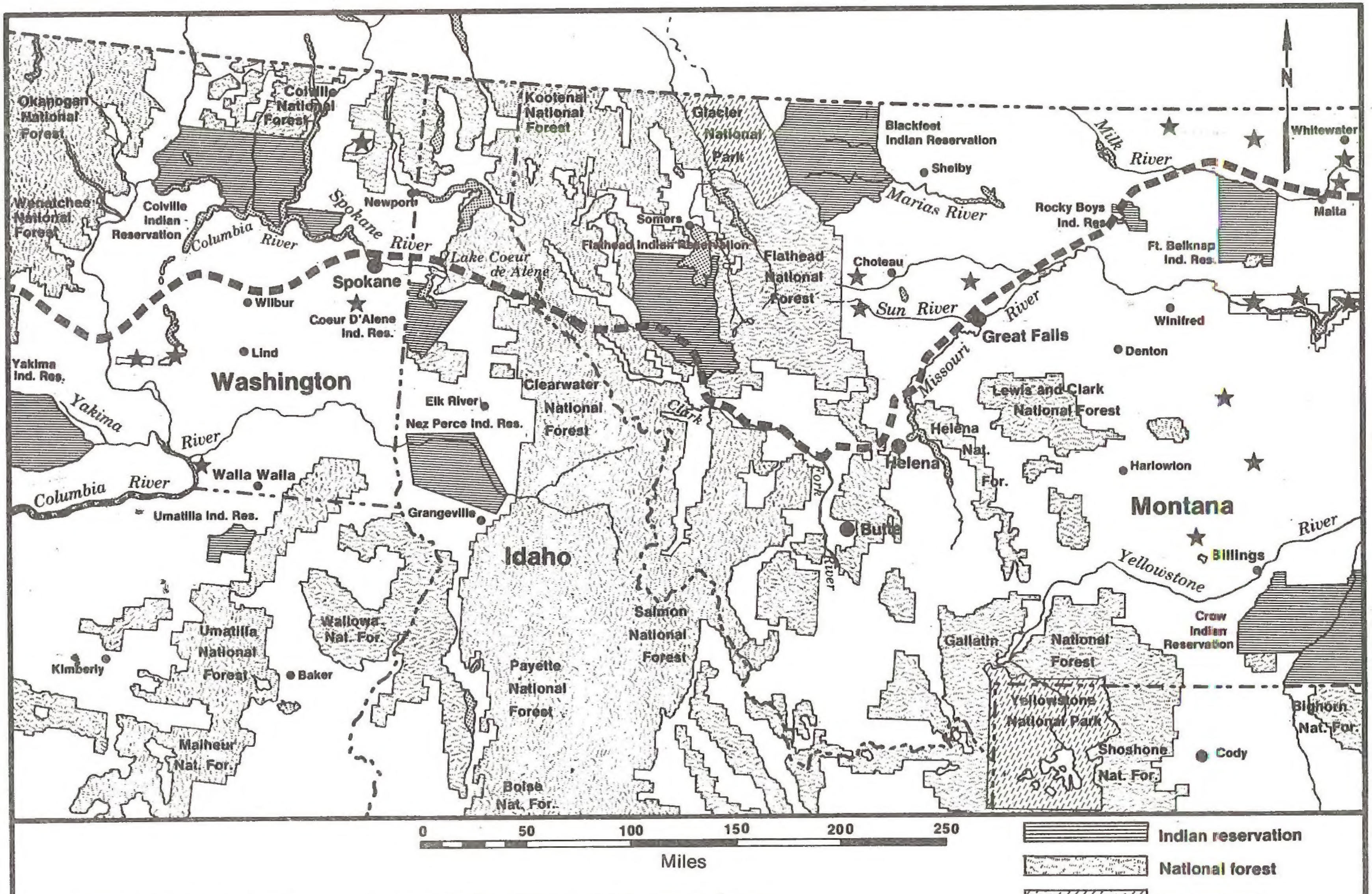


Figure 8.2.3.2-1B Port and Pipeline Alternatives; Puget Sound, Washington, to Clearbrook, Minnesota

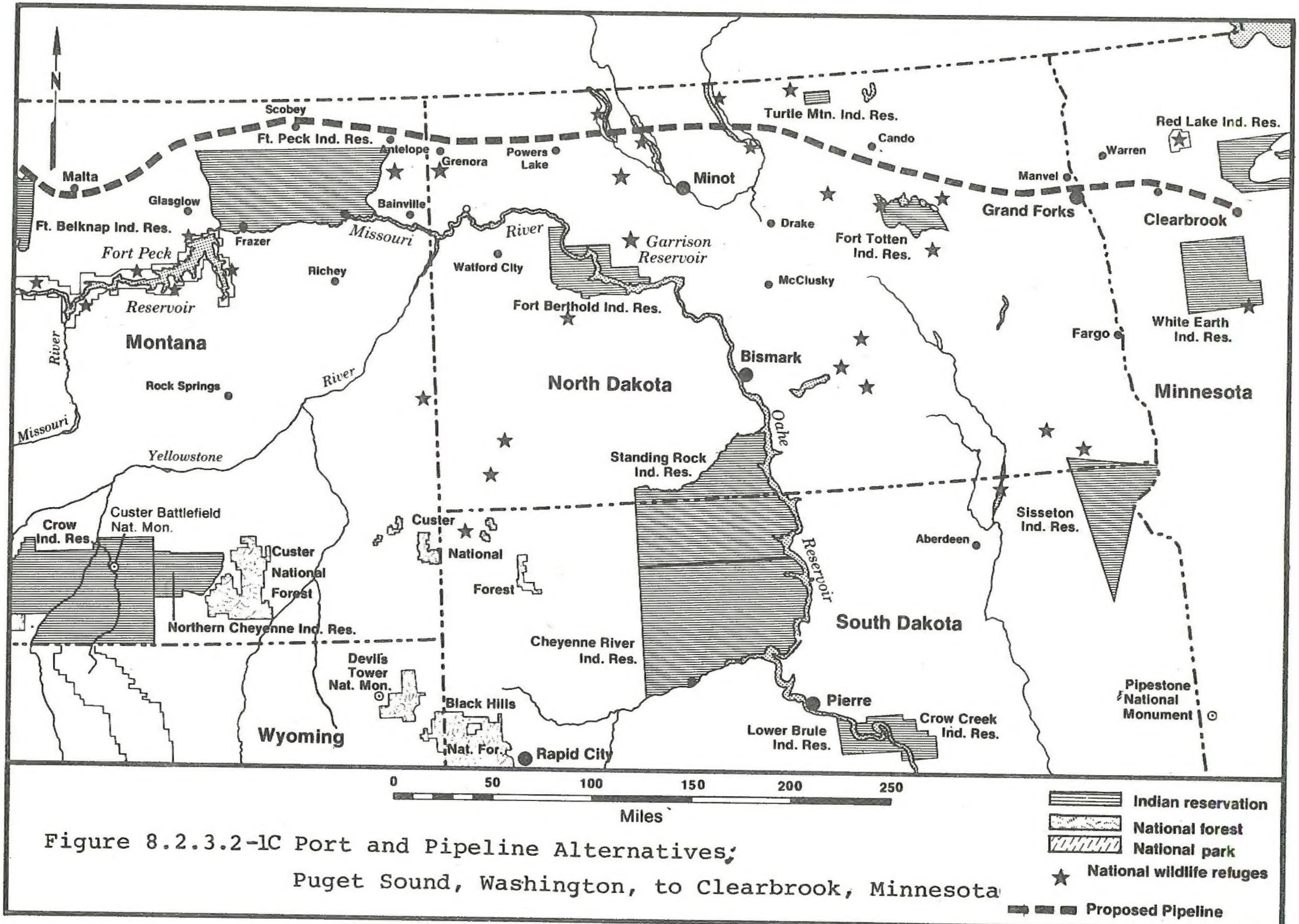


Figure 8.2.3.2-1C Port and Pipeline Alternatives;
Puget Sound, Washington, to Clearbrook, Minnesota

Sequim, passing south of Sequim Bay State Park and Port Discovery. Leaving the railroad corridor, the line would parallel existing transportation and utility rights-of-way for a distance of approximately 76 miles through highly sensitive environs, skirting the Olympic National Forest, traversing the Skokomish Indian Reservation, passing west of Shelton, and crossing the Shelton, Isabella, and Kamicue valleys. Following existing utility corridors, the line proceeds south of Olympia, passing through Tacoma, Sumner, and Auburn to the intersection with the Cherry Point alternative described previously.

The proposed route from the intersection of the north and south Puget Sound connectors would proceed from a point 7 miles above Enumclaw and cross the Cascade Range near the Snoqualmie Pass, through Washington near Spokane, through Idaho at Coeur d'Alene, across Montana near Helena, Great Falls, Harlen, and Glasgow, and through North Dakota near Crosby, Bowbells, Bottineau, and Bisbee. Crossing into Minnesota, the corridor passes south of Thick River Falls and follows an existing pipeline corridor into Clearbrook.

Approximately 934 miles of the 1,680 miles from Cherry Point to Clearbrook would follow railroad right-of-way. The route traverses approximately 96 miles of mountainous terrain (Cascade Range, Bitterroot Mountains, and the Continental Divide), 177 miles of foothills, and approximately 1,300 miles of rolling terrain.

Geology

The proposed northern corridor would pass through areas of medium potential for earthquakes in the Puget Sound area and in western Montana. Approximately 275 miles of the route lie within identified zones (U.S. Geological Survey, 1976) expected to experience a horizontal acceleration in rock of 10 percent of gravity with a 90 percent probability of not being exceeded in 50 years. The proposed route near Helena, Montana, passes

through the most intensive earthquake zone in the United States, with the exception of California and Nevada, with horizontal acceleration reaching 38 percent of gravity.

Such movements could result in rupture of pipelines and damage to pump stations and associated facilities, releasing quantities of crude oil into the natural environment. In the Puget Sound area, such a spill would impact forest and populated areas seriously. It could also enter the waters of the sound as the pipeline route would be proximate to the western shoreline and secondary waterways. In Montana, both forest and foothill prairie areas would potentially be affected.

Terrestrial biology

Approximately 450 miles of the corridor, using Port Angeles as a port of entry, traverses grazed and ungrazed forests. These include the Olympic Peninsula, the Cascade and Bitterroot ranges within or close to the Olympic, Snoqualmie, Wenatchee, Coeur d'Alene, Lolo, and Helena national forests. The highest elevation reached is 6,500 feet. The line would also pass through extensive areas of short and midgrass prairies in Montana and North Dakota and would traverse a region of valuable pot-hole habitat in North Dakota.

Major river crossings involving significant adverse biologic impacts include:

1. Quilcene, Desewallips, Hamma Hamma, Skokomish, Nicqually, Puyallup, and White rivers from Port Angeles port alternative, or

2. Noodsack (twice), Samish, Skagit, Stillaquamish, Snohomish, and Cedar rivers for the Cherry Point port alternative, and

3. Green, Yakima, Columbia, and Spokane in Washington; Coeur d'Alene in Idaho; St. Regis, Clark Fork, Flathead, and Little Blackfoot, Missouri (twice); Sun, Teton, Marias, Milk and Poplar rivers in Montana; DeLacs, Souris (twice), Forest, and Red rivers in North Dakota; and Thief, Clearwater, and Lost rivers in Minnesota.

River crossings in aforementioned Nos. 1 and 2 drain into Puget Sound and have high-value estuaries.

Land use

Following existing railroad and other rights-of-way for the majority of the route, the corridor would traverse areas dominated by grazing or farming activities. Approximately 20 miles of the Yakima Air Force Firing Center in Washington would be traversed. The proposed route would cross approximately 45 miles of the Flathead Indian Reservation in Montana on railroad right-of-way, and traverses national forest land for a total of approximately 110 miles. The line could cross three national wildlife refuges in North Dakota: Des Lacs, Upper Souris, and J. Clark Salyer. Rerouting to avoid these refuges appears to be a feasible mitigation. Much of the proposed corridor through North Dakota and into Clearbrook would cross grasslands interspersed with wetlands as well as lands highly prized for their agricultural productivity. Utilization of existing transportation rights-of-way through this area would minimize impacts.

Land near more intensive human activity, where use of existing rights-of-way is not possible, probably would have the greatest potential for impact. The route from Port Angeles would cross the Skokomish Indian Reservation at the south end of the Hood Canal. This route would also cross areas of varying degrees of population near Olympia and the communities east of Tacoma. Construction activities would probably cut streets and inhibit activity in localized areas for short periods. Permanent placement of the line can be

expected to be a constraint on the location of fixed activities or structures. Coeur d'Alene is also a populated, high land-value area and would have high land-use impacts. Use of existing rights-of-way through this area would appear possible.

Visual and recreational resources. To the extent that it proves practical from an engineering standpoint to utilize existing railroad and electrical transmisssion line rights-of-way, the impacts on visual and recreation resources from pipeline construction and operation will be minimized. However significant deviations from existing railroad and transmission line rights-of-way can be expected in crossing the Cascade Range, the Columbia River, the Coeur d'Alene area, the Bitterroot Range, the Continental Divide near Helena, and the Missouri Breaks area of eastern Montana.

Pump station sites and ancillary transmission line rights-of-way and microwave repeater/reflector sites are likely to have major impacts on visual and recreation resources, but these cannot be analyzed without engineering data on pipeline hydraulics leading to specific site locations for pump stations, coupled with engineering analysis of feasible transmission line/substation taps. Based on moderate to high scenic and recreation values in the Puget Sound, Cascade Range, Columbia River, Coeur d'Alene Lake, Bitterroot Mountains, Missouri River, Missouri Breaks (eastern Montana), and in Minnesota Lakes County, significant adverse impacts on recreation and visual resources can be expected from pump stations, ancillary power lines and microwave repeater/reflector sites, and pipeline alignments outside of existing cleared rights-of-way.

8.2.4 Puget Sound, Washington, to Sidney, Nebraska

A pipeline corridor from Puget Sound to Sidney, Nebraska, is proposed as an alternative for the transport to Kansas and St. Louis, and to Chicago via pipelines from St. Louis. Either Cherry Point, Washington, discussed in Section 8.2.2.1 or Port Angeles, discussed in Section 8.2.3.1 would be the port of entry.

8.2.4.1 Puget Sound to Sidney, Nebraska, pipeline

The proposed pipeline would be approximately 1,400 miles long, traversing Washington, northern Oregon, Idaho, Wyoming, and western Nebraska. Approximately 880 miles of the route would be near existing railroad, highway, product pipeline, and natural gas pipeline rights-of-way.

The route would traverse hilly and mountainous terrain from Puget Sound to King Hill, Idaho, where it would enter rolling semiarid desert areas. The Cascade Range, Blue Mountains, and Medicine Bow Mountains would be the major mountain ranges crossed. Eighteen major rivers crossed would include the Columbia and Snake.

Geology

The corridor in Puget Sound and southern Idaho experiences moderate seismic activity. Earthquakes in Puget Sound are deep in the earth; seismic activity in Idaho is shallow and exhibits significant surface displacement.

Terrestrial biology

The proposed route would pass through relatively undisturbed forest communities, with variations due to elevation and distance from the coast. West of the Cascade Range, forests of spruce, hemlock, cedar, and fir occur. To the east are forests of Ponderosa pine which change to plateau prairies

and sagebrush steppe. Northern subalpine forest may be encountered in places in the Rocky Mountains. Sagebrush steppe and dry prairies would be encountered in eastern Wyoming.

Approximately 250 miles of the proposed pipeline passes through forest areas where existing rights-of-way would not be used. Major river crossings involving significant adverse biologic impacts include:

1. Quilcene, Desewallips, Hamma Hamma, Skokomish, Nicqwally, Pallup, and White rivers for the Port Angeles port alternative, or

2. Noodsack (twice), Samish, Skagit, Stillaquamish, Snohomish, and Cedar rivers for the Cherry Point port alternative, and

3. Green, Yakima, and Columbia rivers in Washington; Grande River in Oregon; Snake, Boise, and Bear rivers in Idaho; and Green, North Platte, and Laramie rivers in Wyoming.

The aforementioned Nos. 1 or 2 river crossings drain into Puget Sound and have high-value estuaries.

In the sensitive areas mentioned above, expected impacts from the installation of a pipeline would include (1) disruption of vegetation habitat and wildlife by construction-related activities, (2) erosion of steep slopes with resulting degradation of streams, (3) clearing of vegetation 75 to 150 feet in width during construction, (4) a permanent 50-foot-wide cleared line to permit maintenance, and (5) recurring disturbance to vegetation and wildlife from periodic passage of vehicles along the right-of-way.

Land use

The predominant land uses along this route are grazed and ungrazed woodland and forest, agriculture, and grazed semiarid desert. The 67-mile segment between Shelton and Buckley, Washington, would have the highest potential for impact from construction-related activities because of several communities and scattered residential areas that would be encountered. The west side of Puget Sound has less intensive land uses but would be a very difficult area in which to mitigate construction impacts, especially along the narrow transportation corridor between the shore of the sound and the mountains, which include the Olympic National Park and Olympic National Forest.

Three miles of Skokomish Indian Reservation (Port Angeles port alternative only), 30 miles of the Yakima Indian Reservation, 20 miles of the Umattilo Indian Reservation and 28 miles of the Fort Hall Indian Reservation would be crossed. Five miles of Warren Air Force Base near Cheyenne also might be crossed. Existing rights-of-way would be utilized for all of these lands, minimizing the impacts of new pipeline construction.

Visual and recreational resources. High recreation and scenic values are encountered by the pipeline in the states of Washington, Oregon, Idaho, and Wyoming in crossing the Cascade Range, Yakima River, Columbia River, Blue Mountains, Snake River, Columbia Plateau broken lands, foothills of the Rocky Mountains, the Great Basin, and Medicine Bow Mountains. While there are existing transportation and utility corridors through these areas, a significant amount of new rights-of-way are projected across national forest lands and National Resource Lands.

Pump station sites, ancillary power-line taps, and microwave repeater/reflector sites cannot be projected without engineering pipeline hydraulics, but these may lead to the most significant impacts. Since much of the country in Washington, Oregon, and southeastern Idaho is forested,

the pipeline and ancillary power lines will create linear swaths that will be highly visible man-made scars on what are now largely natural environments.

Socioeconomics

Significant socioeconomic impacts on community services and possibly housing in small towns along the route and at Sidney, Nebraska, can be expected for the influx of the pipeline, pump station, and tank farm construction workers.

8.2.5 Central Coast, California, to Sidney, Nebraska

This alternative consists of an all-new pipeline to Sidney, Nebraska, from a port on Estero Bay or one of three port sites in San Luis Obispo Bay. See Figure 8.2.5-1A and 1B for geographic location of central California coast port alternatives and pipeline route to Sidney, Nebraska.

8.2.5.1 Estero Bay port

Estero Bay is a broad embayment contained between the headlands of Point Estero on the north and Point Buchon on the south. The coast displays long sandy beaches broken by rocky headlands. The entrance to Morro Bay, an almost landlocked estuary, lies midway between the two points. Morro Bay is one of the most pristine estuaries in California, and has been designated for detailed study by the California Department of Fish and Game. Offshore facilities would consist of three monobuoys connected by submarine pipeline to onshore storage behind the beach and below the steep foothills of the coastal range.

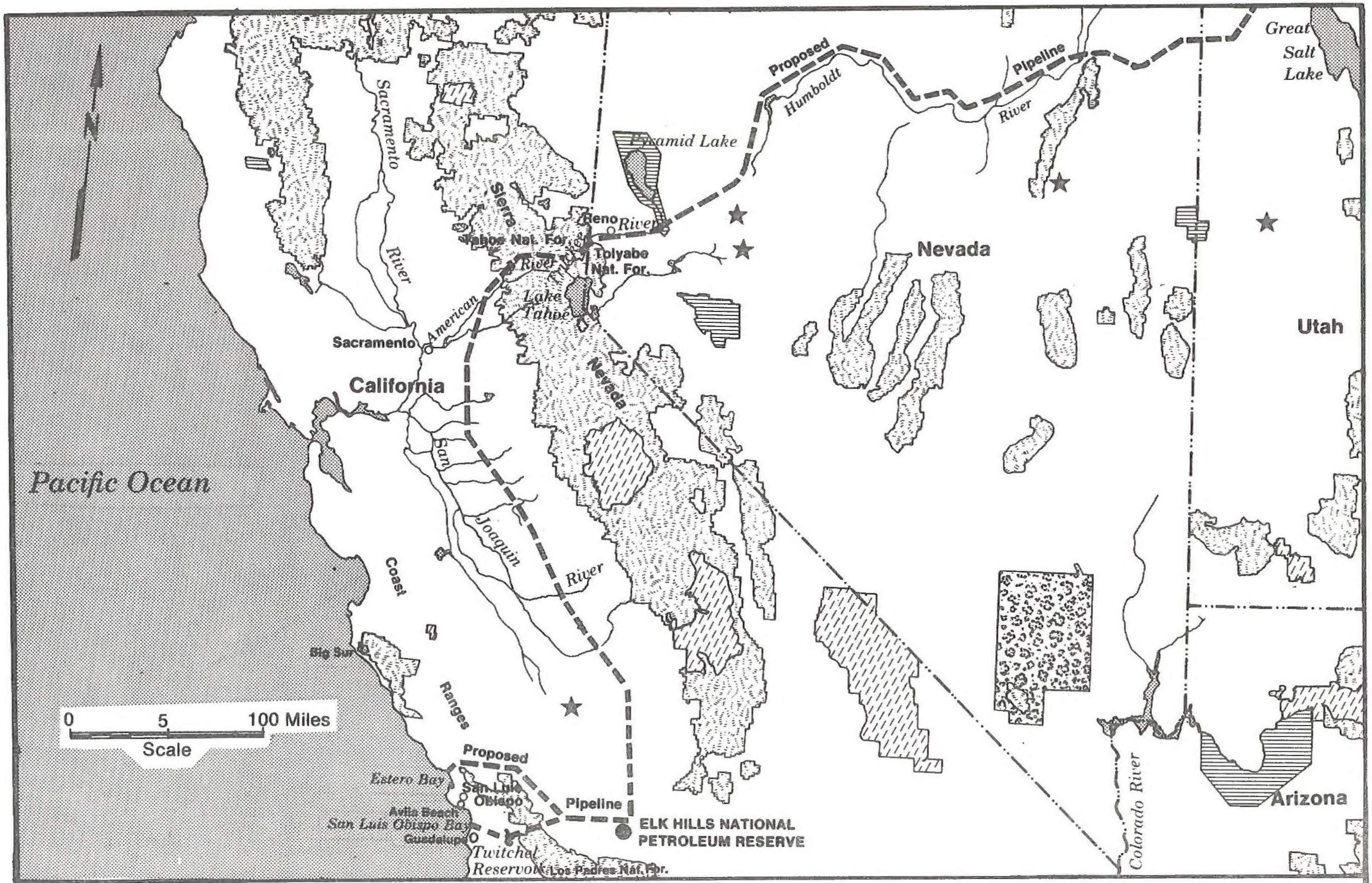


Figure 8.2.5-1A Port and Pipeline Alternatives; Central California Coast to Sidney, Nebraska

Indian reservation
National forest
National wildlife refuge
National park

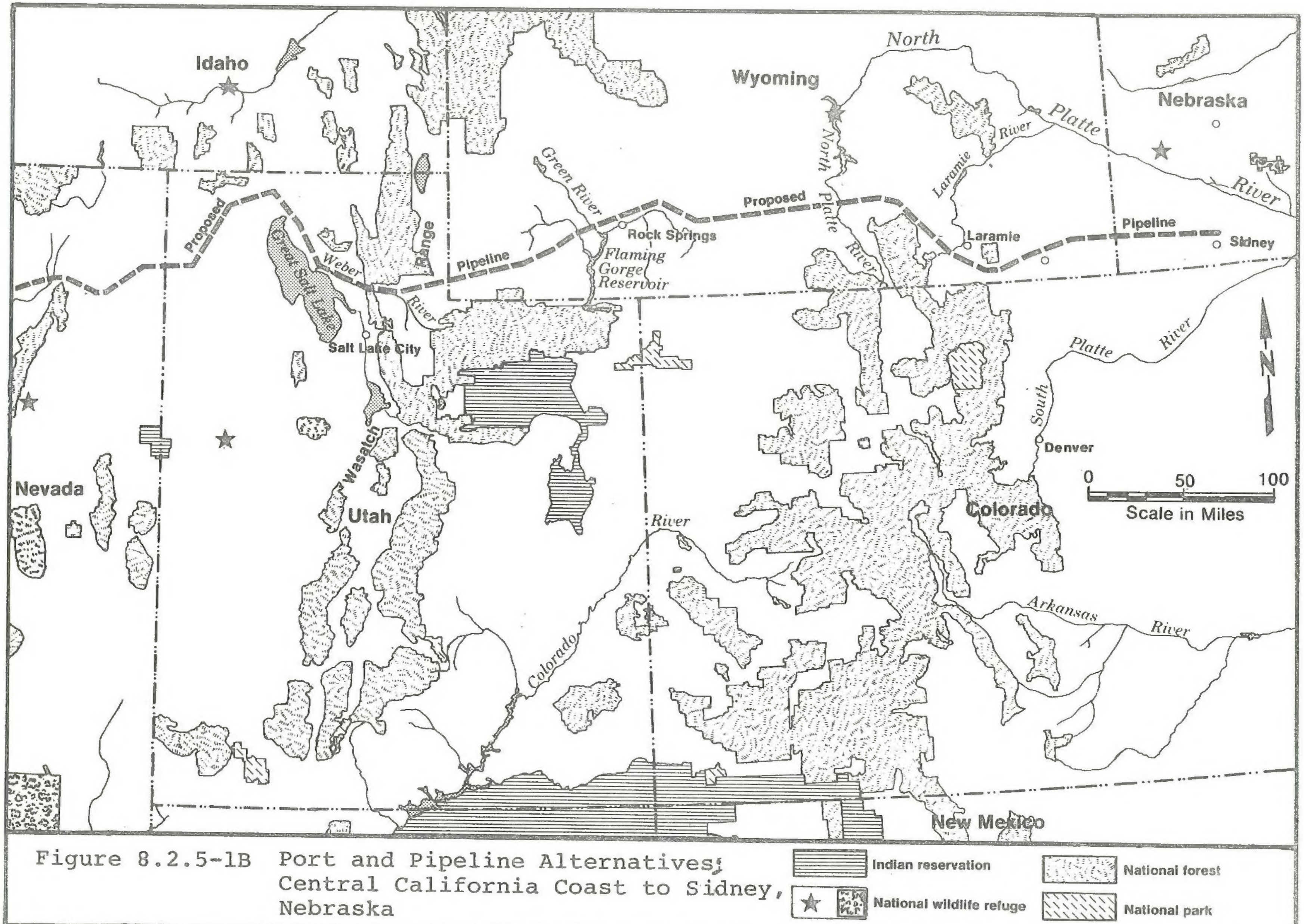


Figure 8.2.5-1B Port and Pipeline Alternatives; Central California Coast to Sidney, Nebraska

Maritime environment

The oceanic environment off Estero Bay is transitional between the stormy northern coast and the mild southern coast. Offshore winds range from 11 to 32 knots, and wave heights from 4 to 14 feet. Offshore currents are weak (less than 0.5 knot), precipitation is infrequent (about 4 percent of the time), and fog is less dense and less common than in northern California (2 to 7 percent visibility less than 1 nautical mile, 12 to 17 percent visibility up to 5 nautical miles).

The central California coastal area has a moderately high commercial ship traffic volume (3,330 ships per year). Standard Oil of California (Chevron) operates one monobuoy off Estero Bay with a total of 179 small tankers using the facility in 1974. Accident rates for the area are not available, but an increase in tanker traffic as a result of the proposal would increase collision risks. From March through November when the southerly Davidson Current prevails, the combined effect of oceanic winds and along-shore current would be to drive oil from a marine spill onto the shore. The impacted area would depend upon the amount of oil spilled, the location of the impacted area, and the amount of weathering. Overall, navigational hazards would be low to moderate because of moderate weather, lack of a narrow approach and strong currents, but a moderately high volume of ship traffic.

Oceanic biology

The area is located in a transition zone between the cold subarctic waters of the north and the warmer subtropic waters to the south. The offshore waters contain a rich assemblage of marine flora and fauna, consisting of a mixture of both warm water and cold water species. Some pelagic species of commercial and sport fishing importance include albacore, Pacific bonito, jack and Pacific mackerel, northern anchovy, and Pacific herring. Important invertebrate fisheries exist for Dungeness crab, ocean shrimp, and squid.

The most important shrimp bed off the central and southern California coast is the area south of Avila Beach, which also sustains a crab industry.

A number of marine mammals occur along the California coast, including porpoises, dolphins, whales, sea lions, sea otters, and harbor seals. The area off Estero and north of Avila is within the protected range of the sea otters. A large herd reportedly resides in the Point Estero area (Corps of Engineers, 1973).

Oil spills occurring offshore could have moderate-to-severe impacts on the oceanic biota. Areas, such as the one frequented by the sea otter herd near Point Estero, would be the most sensitive to impacts of oil spills.

Coastal biology

The water quality in Estero Bay is excellent. The coastal habitat is characterized by (1) rocky shoreline with abruptly rising cliffs interspersed with small pocket beaches, (2) a number of large sandy beaches in the center, and (3) a large tidal estuary and an associated protective sandpit. The intertidal zone of the rocky shore is very narrow, but is bordered by an extensive subtidal rocky reef. A wide diversity of marine algae, which attach to the reef, and localized kelp beds create a highly productive habitat for a multitude of marine organisms. Sports fishing, which is excellent along the rocky shore habitat, includes the red and black abalone. Together, the two species of abalone also account for more than 50 percent of the economic value of the local fisheries.

Morro Bay estuary identified earlier as one of the few bay and estuarine systems remaining in California that is still relatively undisturbed by human encroachment, supports a sports fishery for gaper and Pismo clams. Pacific oysters are taken commercially and are cultivated by mariculture operations in the bay. Dense beds of eelgrass found in the bay provide fish and invertebrates with an important food source as well as serving as a

nursery area for juvenile and larval forms. Harbor seals enter Morro Bay for sun basking and pupping. The range of the Morro Bay kangaroo rat is located near the south side of the bay. The estimated population of this Endangered species is only 3,000 animals.

The bay is also an important feeding and resting area for migratory wildlife in the Pacific flyway. The area is the third most important habitat for the Rare black brant. The great blue heron has established a large rookery in the bay, and a pair of Endangered American peregrine falcons has been known to nest at Morro Rock at the entrance of the bay. The salt marsh provides nesting, feeding, and resting areas for thousands of shorebirds throughout the year and hundreds of thousands of migratory waterfowl seasonally.

Areas especially sensitive to oil spills include wildlife refuges and state parks. Within the area of the proposed alternative site, these sensitive areas would include Baywood Park, southeast of proposed unloading facilities, and Morro Rock Ecological Reserve at the entrance of Morro Bay.

Oil spills could have moderate to very severe impacts on the diverse biota. A computer simulation and drift card studies indicate that if oil were spilled offshore, and not contained, it would probably come ashore (Standard Oil Company of California, 1974). Cleanup of an oil spill before it washes ashore would be very difficult as booms could not contain the oil spill because of wave action. Morro Bay could be relatively easily protected by deployment of a boom across the narrow entrance to keep oil out of the estuary. However, if the crude oil were to enter the estuary, the impacts would be extremely severe. The estuary would itself tend to contain the oil, and cleanup would be difficult and probably damaging. Eelgrass and kelp beds would be damaged and/or destroyed. The overall impacts would significantly affect bird populations, both migratory and residential, marine fish and invertebrates, and marine mammals.

Air quality

The ventilating capacity of the California coast south of San Francisco is limited by the confining influences of coastal mountains and low thermal inversions that cap dense, moist marine air. Limited air pollution data indicate that oxidant levels exceed the Federal standards (0.08 ppm) about eight days per year between Moss Landing to the north and San Luis Obispo Bay to the south. Most data were collected in populated coastal areas. Sulfur and nitrogen oxides levels are below standards.

At Morro Bay there are moderate levels of hydrocarbons from a few petroleum operations; sulfur and nitrogen oxides occur from a power plant. Tanker off-loading and surge/storage tanks would result in a considerable increase of hydrocarbon emissions; tanker stacks would contribute considerable amounts of nitrogen and sulfur oxides and particulates. Violations of oxidant standards would increase. Violations of other standards would be rare. With mitigating measures similar to those committed at Long Beach (access limited to fully segregated ballast, inerted tankers burning low-sulfur bunker fuel), the impacts would be small and of magnitude comparable to Long Beach. (Waste gas stream treatment refinery technology could be incorporated in monobuoy design as a mitigating measure to oxidize hydrocarbon emissions from older tankers; a source of low-sulfur fuel would need development.) The secondary impacts from air pollution would differ somewhat from those at Long Beach. There is a low population density near the Morro Bay terminal that would be exposed to air pollutants; adverse impacts on aesthetics and recreational resources would be higher. There would be some general air quality benefit in terminating the tanker route short of Point Conception.

Geology

Compared to other sites in coastal California, Estero Bay is a relatively quiescent seismic area. Some of the faults in the area include the San Andreas fault, 48 miles; Rinconada fault zone, 18 miles; San Juan fault, 40 miles; and Nacimiento fault, 9 miles. The probable ground acceleration, experienced in the 50-year earthquake, was calculated to be only 0.28 g. Liquefaction of the sediments could occur during an earthquake, and the area is susceptible to landslides (Standard Oil Company of California, 1974). The Standard Oil report (Estero Bay deep tanker terminal proposal) also identified a tsunami risk for the area.

Terrestrial biology

The upland area is relatively undeveloped. All of the major vegetation communities are found, including coastal strand, coastal sage scrub, chaparral, oak woodland, and grassland. Coastal agriculture and urban areas are interspersed with natural communities. Abundant wildlife in the area includes harvest mice, rabbits, mule deer, raccoon, coyotes, sparrows, western meadowlarks, owls, quail, and warblers. State parks in the area include Morro Bay and Montana De Oro state parks. The Los Padres National Forest is in the area.

Construction of onshore terminal and storage/surge facilities as a result of the proposal will remove only a relatively small area of natural habitat, probably grazing land. However, ancillary development would result in serious potential impacts to the natural environment. Major industrialization or population growth at Morro Bay, Baywood Park, or the city of San Luis Obispo would greatly alter the present undisturbed character of San Luis Obispo County.

Land use

The dominant land uses of Estero Bay are agricultural and recreational. However, Standard Oil of California (Chevron) does have a monobuoy offshore and storage tanks onshore. Land is available, but conflicts may arise with existing uses from rezoning for industrial land use.

Visual and recreational resources. Development of an onshore port terminal tank farm, within the coastal zone would conflict with the visual guidelines in the California Coastal Plan. The facilities would be highly visible to recreationists along the coast, and motorists on U.S. Route 1, a designated scenic highway. Transshipment facilities may inhibit access to the coastal zone, where three state beaches provide public recreation opportunities. Chronic oil spills from monobuoy operations would wash ashore on these public beaches, degrading the recreational experience with the possibility of partial closure of the beaches until cleanup could be effected.

Socioeconomics

Development of a transshipment facility would lead to socioeconomic change. Morro Bay, population 8,000, is rural, with a labor infrastructure based on agriculture and recreation. Workers and services to support an oil terminal would have to be brought in. Socioeconomic impacts upon the Estero Bay communities would be moderate to severe, depending on whether crude oil industries, such as refineries or petrochemical plants, also developed as a result of the availability of crude oil.

8.2.5.2 San Luis Obispo Bay, California, port alternatives (Avila Beach, Oso Flaco, or Guadalupe Dunes)

Avila Beach, Oso Flaco, and Guadalupe Dunes, three alternate ports of entry on San Luis Obispo Bay, are considered jcintly because of geographic proximity. Avila Beach and Oso Flaco are located in San Luis Obispo County about 25 and 40 miles south and east of Morro Bay. Guadalupe Dunes is

located 10 miles farther south in Santa Barbara County. The coast of the northern area, Avila Beach to Shell Beach, is predominantly rocky, supporting a rich and diverse flora and fauna. The southern coast near Oso Flaco and Guadalupe Dunes is predominantly broad expanses of smooth, sandy beaches. Offshore facilities at the two sites would be similar to the Estero Bay alternative and would consist of three monobuoys connected by submarine pipeline to onshore storage. Onshore storage facilities would probably be located behind the beach (but below the steep foothills of the coastal range at Avila Beach). The following discussion of environmental parameters refers extensively to the previous site discussion of Estero Bay (Section 8.2.5.1).

Maritime environment

The climate of the Avila Beach, Oso Flaco, and Guadalupe Dunes area is typical of the central California coast with warm dry summers and cool moist winters. Storms usually occur between November and April and can spawn heavy seas. Tropical summer storms to the south often produce large waves (more than 15 feet) on south-facing beaches, particularly Avila Beach. Offshore and nearshore currents are weak, usually less than 1 knot. Commercial ship traffic (3,300 ships per year along the central California coast) is moderately heavy and could pose collision risks for tankers traveling from sea lanes to the two sites. A total of 96 small tankers used the Union Oil Company facilities at Avila Beach. Overall navigational risks are moderate, influenced by a high ship-traffic volume, moderate weather conditions, and the lack of a narrow approach and strong currents.

Oceanic biology

The oceanic environment, as described under the Estero Bay alternative, is characterized as a rich transitional assemblage of marine flora and fauna. The area is within the southern range of the California sea otter. The Pismo clam beds between Pismo Beach, Oso Flaco, and Guadalupe Dunes are the

most important ones located off the central and southern California coast. This area also sustains a crab industry. Marine mammals are found in the area, including seals, sea lions, sea otters, whales, and dolphins. Fish are numerous, and many important commercial and sport species are abundant.

Overall, impacts from the proposed action would be moderate to severe, depending on the number and size of oil spills and where the spills occurred. Currents in the area would tend to carry the oil onshore, increasing the severity of impacts. Containment of oil spills by booms before they reached shore would be very difficult because of wave action.

Coastal biology

The following discussion is divided into three areas: the rocky coast, characteristic of the Avila Beach area; the sandy coast, characteristic of the Oso Flaco and Guadalupe Dunes areas; and anadromous streams. In San Luis Obispo Bay, there is no opening to a large, extensive estuary such as Morro Bay off Estero Bay. Though less productive than Estero Bay, the area still supports an abundant, diverse biota.

Rocky substrate. Off Avila Beach, the shoreline is a series of sheer, wave-eroded cliffs, jutting headlands, and massive offshore rocks and reefs. The tidal zone is narrow. The rocky areas support the most varied and most luxuriant algae communities of the area. Intertidally, 113 species of marine algae and flowering plants have been identified, and subtidally 66 species of marine algae. Much of the algae provide vital food and shelter for many species of invertebrates and fish, including black and red abalone, turban snails, sea urchins, pricklebacks, and rockfish. Surfperch, rockfish, ling cod, and cabezon are important in sport fishing and commercial fisheries of Avila Bay.

Sandy substrate. Off Oso Flaco and Guadalupe Dunes, the shoreline is a broad expanse of smooth, sandy bottom. The area has a relatively

depauperate assemblage of marine organisms compared to the rocky substrate areas off Avila Beach. Prominent species in the area include surfperch, juvenile and adult flatfish, a few species of rockfish, and clams. The sandy coastline along Pismo Beach is the site of a large concentration of clams.

San Luis Obispo County contains the southernmost streams along the California coast where anadromous breeding occurs. Anadromous streams refer to certain unobstructed, coldwater streams with adequate perennial water flows or intermittent periods of high runoff. Anadromous streams in the area include Villa, Morro, Charro, San Luis Obispo, and Pismo creeks.

Three species of Endangered birds have been reported from the coastal areas. They are the California brown pelican, identified in Morro Bay and near the mouths of Pismo and San Luis Obispo creeks; the American peregrine falcon, a nesting area on Morro Rock; and the California least tern, seen near the Dune Lakes area.

Avila Beach, Oso Flaco, and Guadalupe Dunes are in one of the most critical coastal environments in California, the zone of transition from the warmwater habitats of southern California to the cold-water habitats of northern California. Both sites are extensively used for recreation. If a major crude oil spill occurred, the damage to marine life could be expected to be very severe.

<u>Air quality</u>

The air quality of the three sites is similar to Estero Bay (see the discussion of air quality in Section 8.2.5.1). The adverse and beneficial impacts from locating the terminal at any of these sites would also be comparable.

Geology

Avila Beach, Oso Flaco, and Guadalupe Dunes are within 50 miles of major geologic faults. The principal faults are the San Andreas and the Nacimiento. Probable ground acceleration from a 50-year earthquake is the same as for Estero Bay area, 0.28 g. At present, there is lack of information regarding the sediment stability and potential ground failure at both sites.

Susceptibility to soil erosion is a significant problem, especially near Avila Beach and Oso Flaco Lake. High vulnerability to soil erosion damage near Avila tends to be related to extensive areas of underlying Franciscan deposits on steep contours. Near Oso Flaco Lake, the susceptibility of sand dunes to eolian and fluvial forces is responsible for the severe erosion hazard.

Terrestrial biology

Dominant plant groups are grasslands, savannahs, and chaparral. Minor constituents are woodlands and agricultural lands. The distributional patterns of the natural vegetation are governed by such factors as rainfall, solar radiation, soil texture, and fertility. This mosaic of habitats can accommodate a rich and diverse variety of wildlife species. Three ecologically sensitive areas with Rare and Endangered vegetation species are Hazard Canyon, an area with many endemic plant species and a Rare species of manzanita; Indian Knog, an area located 5 miles south of San Luis Obispo with a very Rare flowering shrub; and Pismo Dunes, an area south of Oceano with a wide variety of Rare species found in the sand dunes. Located in the more rugged, remote areas is the Endangered California condor. Two nest sites exist in the La Ponza range.

Onshore construction of terminal and storage/surge facilities would remove only a relatively small area of natural habitat. However, ancillary

development would result in serious potential impacts on grazing land. Damage and/or destruction of Endangered species of vegetation and wildlife might result.

Land use

The coastal region north of Avila Beach contains recreational, open space, and agricultural land uses. Inland, the land use is primarily agricultural. Union Oil maintains a pier for oil tanker mooring and onshore pumping and oil storage tanks at Avila Beach. Port San Luis (1 mile west of Avila Beach) has moorings for 300 craft, the majority being pleasure and fishing vessels.

At Avila Beach the impacts of construction activities on the topography would be severe. Avila Beach is surrounded by abrupt hills rising some 500 feet above sea level. Extensive areas of the hills would have to be blasted and excavated. Drainage patterns and potential water erosion could also be affected.

The Oso Flaco and Guadalupe Dunes areas are undeveloped areas south of Pismo State Beach. Primarily uninhabited, the sand dunes are extensively used by recreational vehicles. A Union Oil refinery and a Collier Carbon Corporation plant are located inland near Oso Flaco Lake. The area inland of Guadalupe Dunes is rural agricultural lands.

Construction activities at Oso Flaco or Guadalupe Dunes would have an adverse impact on the dune formations and flora. The facilities could be located inland from the dunes, but even construction of a pipeline through the dunes would destroy a section of vegetation and alter the dune formation, which would precipitate wind erosion and shifting of otherwise stabilized dunes.

Visual and recreational resources. Development of an onshore port terminal tank farm within the coastal zone would conflict with the California Coastal Plan visual quality guidelines. The Avila Beach site would be highly visible to recreationists using the coast and to motorists on U.S. Route 1, a designated scenic highway. Development at Oso Flaco or Guadalupe Dunes conversely may be screened by topography from view. Chronic oil spills from monobuoy operations would wash ashore on Pismo State Beach, degrading the recreational experience with partial closure possible until cleanup was affected. The Pismo clam is a valuable recreational resource which would suffer a decline. Cleanup of oil spills washed ashore on rocky Point San Luis or Avila Beach would be extremely difficult.

Socioeconomics

Socioeconomic impacts at all three sites would be similar to those of Estero Bay. Development of a transshipment facility would lead to socioeconomic change. The labor infrastructure is based primarily on agriculture and recreation. Construction workers brought in to construct an oil terminal would strain community services including schools, hospitals, and police protection as well as the housing market for the short term. Long-term impacts on the socioeconomic structure of an oil port in San Luis Obispo Bay at one of the three alternative sites could be moderate to severe, depending on the magnitude of ancillary development.

8.2.5.3 Central California coast to Sidney, Nebraska, pipeline corridor

One proposed corridor would originate at Estero Bay slightly north of the community of Morro Bay, and it would almost immediately enter the foothills of the Santa Lucia Mountains just south of Whale Rock Reservoir. The proposed routing would require a slight northeastward trend to take advantage of the gentler slopes and lower elevations. This corridor would allow the selection of right-of-way north of the boundaries of the Los Padres National Forest. The corridor would continue to the Salinas River

which is the primary watershed of the central California coastal ranges and then cross the Temblor range to the Elk Hills Petroleum Reserve.

A second proposed corridor, the Avila Beach alternative line, would proceed southeasterly from Avila Beach for approximately 20 miles through farm and ranch country north of Arroyo Grande, then enter Los Padres National Forest and skirt north of Twitchell Reservoir. From there it would proceed northeasterly through Shaw Canyon, Branch Creek, and Brown Canyon, cross the Pillitas and Branch mountains and descend into the Carrizo Plain south of Great Soda Lake. The line then would cross the Temblor Range through Crocker Canyon Pass and descend through Buena Vista Valley to Elk Hills Petroleum Reserve approximately 7 miles north and east of Taft.

A third proposed corridor from Oso Flaco on the Guadalupe Dunes line would proceed due east through the Santa Maria Valley, Nipomo Mesa, cross Highway 101 and enter Los Padres National Forest and skirt south of Twitchell Reservoir. The line then would turn northeasterly into the Stanley Mountains, follow Alamo Creek and Jollo Creek into Shaw Canyon where it would join the proposed line from Avila Beach.

The coastal plains are narrow and discontinuous throughout this southern section of the coastal range resource area. A variety of productive soil types, especially the alluvial topsoils associated with the narrow floodplains of the Salinas River and the narrow stream valleys draining the mountain ranges, support intensive agricultural interests eastward to the Carrizo Plain, San Luis Obispo County. This section of the proposed alternative corridor presents considerable contrast in productivity, topography, climatic conditions, and aesthetic values. Extensive dry farming and small irrigated plots support productive grain-farming operations, some orchard production, and truck crop production. The remainder of the gentler sloping bases of the mountainous sections are used for grazing on a cover of native grasses in relatively sparse stands of woodlands. There are erosional problems on the steeper slopes of the ranges

that are unpredictable because of the broad differences in seasonal and annual precipitation. Varying from 12 to as much as 40 inches per year, much of the precipitation may come in heavy rainstorms, and it may result in extensive surface soil erosion and some small landslides where the stream valleys empty onto the flat valley basins.

At the Elk Hills Petroleum Reserve, the line would turn north through the San Joaquin Valley following existing transportation corridors for the majority of the route.

The San Joaquin Valley supports extensive farming operations with more than 90 percent of the entire area in farms and ranching operations. The corridor traverses croplands (75 percent irrigated) producing cotton, fruits, nuts, and grapes, and irrigated improved pasture for grazing and hay production. In both urban and rural areas many transportation corridors must be crossed. The primary agricultural topsoils, of which most of the valley plains are made up, are humic clay and alluvial soils produced by erosional evolution from the Sierra Nevadas.

The proposed corridor would follow existing right-of-way through the Tahoe National Forest, one of the largest units in the National Forest System. Tahoe National Forest supports significant timber, wildlife, floral, and recreational resources.

Near the California-Nevada boundary, the corridor would enter a more arid environment. After crossing the Truckee River, the route would pass immediately north of Reno. The proposed corridor would continue northeastward through the steep slopes and narrow canyons of the Pah Rah Range. This area is largely uninhabited, and supports a sagebrush environment with some areas of pinyon-juniper, Jeffery pine, and irrigated agricultural lands immediately adjacent to the Truckee River.

After passing through the Pah Rah Range, the proposed corridor would continue to follow Interstate 80 and cross the boundaries of the extreme southern portion of the Pyramid Lake Indian Reservation. From the Washoe-Churchill County boundary, the corridor would parallel I-80, following existing right-of-way generally eastward in the Humboldt River valley across most of Nevada to near Wells.

The paucity of water supplies from all sources limits agricultural and wildlife production through this area. However, major areas adjacent to the Humboldt River are irrigated and are utilized largely for hay production. Other large areas in the Humboldt Valley are used for livestock grazing. The river valley is a concentration area for wildlife in the region.

Several Indian reservations are crossed or are located closely along the corridor through Nevada, including the Reno-Sparks, Pyramid Lake, Lovelock, Winnemucca, Battle Mountain, and Elko reservations.

From Wells, Nevada, the corridor generally would parallel I-80/U.S. Route 40 across several ridges and basins to the Utah border. Skirting to the north of the Great Salt Lake Desert and Great Salt Lake, the corridor would continue to follow highways across the largely uninhabited sage desert landscape to the Ogden urban area.

Immediately south of Ogden the route would follow U.S. Route 30 and Interstate 80N up the narrow Weber River canyon through the Wasatch Range. For about 6 miles the corridor would traverse the boundary area between Cache National Forest and Wasatch National Forest. Through the Wasatch Range most of the higher elevations and steeper slopes are forested; sagebrush is dominant at lower elevations and in the broader valleys. Some irrigated fields are located along the route in the broader portions of the Weber River valley. Gray wooded soils are dominant in the forested areas, and lithosols and rock outcrop dominate the steeper slopes.

The Weber River valley through the Wasatch Range is of high scenic value. The highways through the area attract significant numbers of sightseers and recreationists. The area also supports a wide variety of big and small game animals, including introduced species from other areas where adverse habitat conditions have occurred.

Several miles after leaving the mountains, the corridor enters Wyoming and traverses the entire state roughly paralleling I-80/U.S. 30. Over most of this distance the route passes through a high rolling, sage-covered plain interspersed with occasional ridges. The Red Desert is crossed between Rock Springs and Rawlins. Much of the land along the corridor is in Federal ownership and is under the control of the Bureau of Land Management. Between Rawlins and Laramie the corridor passes within 2 miles to the north of the Medicine Bow National Forest. Just west of Laramie, the corridor passes through 5 miles of the national forest, a heavily used recreational area with developed facilities in the immediate corridor.

Other potentially sensitive areas through Wyoming include several river crossings. The Bear River, Black Fork, the Green River (approximately 5 miles above Flaming Gorge National Recreation Area), the North Platte River, and the Medicine Bow River, would all be traversed by the corridor, and all possess significant wildlife, fishery, vegetation, recreation, and water supply values.

The proposed corridor would pass within about 5 miles of Cheyenne, through the boundaries of Francis E. Warren Air Force Base, and within the land parcels being used in research by the University of Wyoming Agricultural Experiment Station, west of Cheyenne. East of Cheyenne the route would pass through predominantly agricultural land along I-80 to Sidney, Nebraska. Major dry farming and irrigated areas produce wheat and other grains as well as hay and grasses for livestock feeding and pasturing.

Visual and recreational resources. The pipeline would traverse a number of areas of high scenic quality with high visual sensitivity including the California Coastal Ranges, the Sierra Nevadas, the Weber River Valley through the Wasatch Range and national forest lands west of Laramie. These areas also have high recreational values. Long-term visual scars would result from the clearing of swaths through forested areas.

8.2.6 Central California coast to Midland, Texas

The previously discussed port alternatives of Estero Bay and San Luis Obispo Bay (Avila Beach, Oso Flaco, and Guadalupe Dunes) would be utilized (see Sections 8.2.5.1 and 8.2.5.2). The project would connect with the proposed SOHIO pipeline at Redlands.

Alternative pipeline corridors from Estero Bay, Avila Beach, and Oso Flaco/Guadalupe Dunes to the Elk Hills Petroleum Reserve are discussed in Section 8.2.5.3. From Elk Hills, the line would run south through the extreme southern portion of the San Joaquin Valley; and eastward to the foothills of the Tehachapi Mountains. Ascending into the Tehachapi Mountains, the route then would pass through Cummings Valley and Tehachapi Valley, and enter the Mojave Desert. It then would proceed southeasterly past Edwards Air Force Base, and continue through the Mojave Desert south of Joshua Tree State Park to Cajon Canyon, crossing the San Bernardino Mountain over Cajon Pass though the San Bernardino National Forest, then pass to the west and south of the city of San Bernardino to a point of the main Long Beach-to-Midland proposed pipeline route near Redlands.

The Redlands-to-Midland portion of the pipeline would be the same as that of the SOHIO proposal.

Geology

The important geological feature of this alternative, similar to all southern California routings, centers on the seismic activity of the pipeline alternative. At least 19 major faults, both active and inactive, are crossed by this alternative route. The routing has 36 percent of its length in Seismic Risk Zone 3, and 45 percent of its length in Seismic Risk Zone 2. The remaining 19 percent of the route is in Seismic Risk Zone 1. The California segment of this alternative is considered to be in Seismic Risk Zone 3.

Terrestrial biology

The vegetation in the region of Estero Bay rises from the salt marshes of the coast to the California oak woodland of the Santa Lucia Mountains. The California oak woodland contains a mixture of pine and oak trees. Portions of this area have been set aside for the Los Padres National Forest. Passage along the periphery of this forest and into the southern end of the San Joaquin Valley would encounter the disturbed area of the California steppe, replaced by cultivation, grazing, and exotic grasses (presently termed California grassland). Continuing southeast, the route would encounter the low shrubs of the saltbush-greasewood vegetal zone near Bakersfield, and pass again into a grassland community in the Tehachapi Mountains. The vegetation transition into Antelope Valley would provide a desert environment in which the dominant species is creosote bush.

The route would pass in the vicinity of the Sisquoc California Condor Reserve and the Tule Elk State Reserve. The California condor is one of the most protected of bird species; it feeds in the vicinity of the proposed route. The Tule Elk State Reserve is located near Bakersfield. It could be avoided by the route.

Land use

Land uses along the pipeline route from the central California coastal area to Redlands are largely rural with some agricultural lands. Much of the land is open space grazing.

Visual and recreational resources. The route from the Elk Hills Petroleum Reserve would traverse the San Bernardino National Forest over Cajon Pass, an area of high visual sensitivity and high scenic value with high recreational use as well.

8.2.7 Ventura County, California, to Midland, Texas

This alternative consists of development of Port Hueneme/Oxnard as a port of entry with offshore monobuoys, and construction of a pipeline to Redlands, California. From Redlands to Midland, Texas, the route is identical to that of the SOHIO proposal. See Figure 8.2.7-1 for geographic location of port and pipeline routing.

8.2.7.1 Port Hueneme/Oxnard and Deer Creek (Ventura County), California

Port Hueneme is located about 65 miles northwest of Los Angeles-Long Beach Harbor. Commercial vessels and military craft, carrying cargo to the U.S. Navy base, utilize Port Hueneme. This alternate site would use offshore monobuoys. Onshore facilities would be located near Oxnard.

Maritime environment

The ocean environment is mild. Winds average 10 knots with typical maximums of 31 knots. Waves average 2 feet and occasionally reach 10 feet under storm conditions. Currents are weak, usually less than 1 knot. Moderate fog may occur offshore, but generally visibility is good (visibility under 1 nautical mile for 1 to 15 percent of the time). The coastal area has a

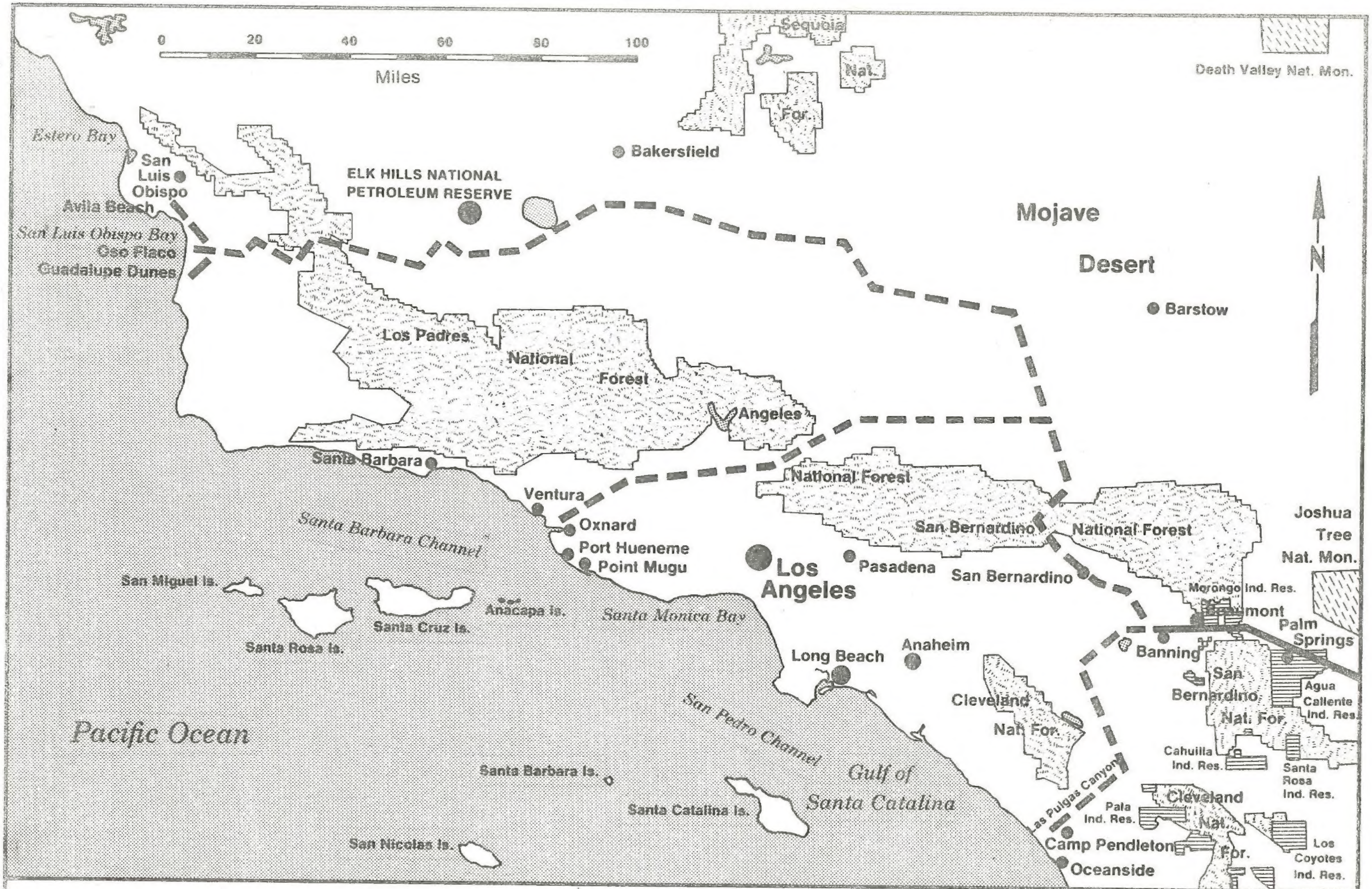


Figure 8.2.7-1 Port and Pipeline Alternatives; Central California Coast, Port Hueneme/Oxnard and Camp Pendleton tie-in to Elk Hills

moderately high volume of commercial ship traffic (3,300 ships per year). A total of 54 small tankers used the Port Hueneme berthing facilities in 1974.

Oceanic biology

The oceanic biology of the Port Hueneme area is very productive. Located 20 and 25 miles offshore of Port Hueneme are the Anacapa Islands and Santa Cruz Island. These islands represent a unique area of biologically rich, undisturbed habitat for kelp and other algae, invertebrates, fish, marine mammals and marine-associated avifauna. The islands serve as crucial refuges for associated avifauna and such marine mammals as California and Steller's sea lions, harbor seals, and northern elephant seals.

Tanker traffic, and consequently oil spills, reaching the Channel Islands could have very serious impacts, including reductions in the populations of marine mammals, fish, birds, invertebrates, and plants, disruptions of ecosystems and alterations of biological habitats.

Coastal biology

The coastline near Port Hueneme is predominantly sandy beaches which are habitat areas for populations of clams, sand crabs, and polychaetes. Species of commercial and sport fishing value include surfperch, northern anchovy, drums, midshipmen, rockfish, white sea bass, and barred sand bass. Although the area is not prime habitat for seabirds, more than 50 species have been reported in the area, including the least tern and brown pelican.

Mugu Lagoon is located 7 miles south of Port Hueneme. The estuary-lagoon system supports a rich variety of vegetation, invertebrates, fish, and birds. The area from Mugu Lagoon to Latigo Point has been designated an Area of Special Biological Significance by the State Water Resources Control Board (Resolution No. 74-28). The designation of the area affords special

protection for marine life to the extent that waste discharges are prohibited within the area.

The coast is moderately to acutely sensitive to oil pollution. Mugu Lagoon would be the most sensitive area of the coastal environment near Port Hueneme. Possible effects of oil spills would include reductions in populations of marine vegetation, invertebrates, fish, birds, and destruction or alterations of the diverse biological habitats.

Air quality

The poor ventilating capacity of these sites is comparable to that for sites farther north in California (Section 8.2.5.1). Current emissions levels are higher. Consequently, the Federal oxidant standards are violated more frequently; during 1973 through 1975, the oxidant standards were exceeded 65 days each year at Mandalay Beach and 36 days at Ormond Beach and Mugu Lagoon (FEA, 1976). The California one-hour nitrogen dioxide standard (0.25 ppm) was violated approximately 5 days each year.

Emissions from older tankers with insufficient segregated ballast would pose a serious oxidant problem; the oxidant standards would be subject to additional violations. With mitigating measures as effective as those committed at Long Beach (see Section 8.2.5.1), the adverse impact would be similarly small. Additional facilities would be necessary to provide tankers with low-sulfur fuel; if provided, the impact resulting from sulfur oxides would be slightly smaller than at Long Beach owing to remoteness of the monobuoys from shore. It is unlikely that the project would cause further violation of the nitrogen dioxide standard or any violations of sulfur oxides or particulate standards.

Geology

Port Hueneme is within the shaking zone of three or four major faults, including the Oak Ridge, the Malibu Coast, the Santa Cruz, and the distant San Andreas. Bedrock acceleration from a 50-year earthquake is estimated to range from 0.2 to 0.4. The coastal area near Port Hueneme is composed of sand and alluvial creek sediments, and therefore probably should be considered to have a high liquefaction potential. The offshore sediments would be expected to be similar.

Terrestrial biology

The upland habitats in the area are predominantly disturbed. Onshore construction of terminal and storage/surge facilities would not destroy any rare or sensitive habitats in the immediate area of Port Hueneme.

Land use

The predominant land uses of the Port Hueneme/Oxnard area are residential, agricultural, and recreational with limited industrial developments. Industrially zoned lands may be available and a U.S. Navy base is located at Port Hueneme. Nevertheless, significant land-use conflicts could arise from the development of the transshipment project and/or ancillary oil-related facilities.

Visual and recreational resources. Development of an onshore port terminal tank farm within the coastal zone would conflict with the California Coastal Plan's visual quality guidelines. The dune area at Ormond Beach near Port Hueneme has high scenic and recreational values and is proposed for State Park acquisition. The Deer Creek alternative lies between Point Mugu State Park and Leo Carrillo State Park with the highly scenic coastline between the two state parks proposed for acquisition by California State Beaches and Parks. Chronic oil spills associated with monobuoy operations off either

site would wash ashore on public beaches, resulting in degradation and possible closure until cleanup could be effected.

Socioeconomics

Socioeconomic impacts probably would be slight although Port Hueneme, population 2,000, is not predominantly industrial. Oxnard, population 71,000, is about 1 mile from Port Hueneme and has a large industrial work force. Adequate support facilities should be available for the proposed project.

8.2.7.2 Port Hueneme (Ventura County), California, to Midland, Texas

The proposed pipeline routing from Port Hueneme would proceed in a slight northeasterly direction following existing railroad and highway corridors through the communities of Camarillo and Moorpark to a point south of Oxnard Air Force Base. The line would then turn due north traversing Oak Ridge to Fillmore, picking up an existing railroad corridor, and proceeding easterly to Castaic Junction along the Santa Clara River. Crossing Interstate 5 below the Angeles Forest, the route would proceed near Saugus to Mint Canyon and follow State Highway 14 through Palmdale and Lancaster and connect with the previously described pipeline alignment from the Estero Bay-San Luis Obispo Bay alternatives near Edwards Air Force Base.

The environmental constraints for this proposed routing are similar to those described for the Estero Bay-San Luis Obispo corridor routing (Section 8.2.6).

8.2.8 Camp Pendleton, California, to Midland, Texas

This alternative consists of development of Camp Pendleton as a port of entry with offshore monobuoys and construction of a pipeline to Beaumont, California. From Beaumont, California, this alternative is identical to the SOHIO proposal.

8.2.8.1 Camp Pendleton, California, port alternative

Camp Pendleton is located between San Clemente and Oceanside. No commercial port facilities are in the vicinity. The project would use offshore terminal moorings linked to onshore facilites by a submarine pipeline.

Maritime environment

The ocean environment, typical of southern California, is generally mild. Wind speeds and wave heights are moderate. Currents in the area are weak, less than 1 knot, and fog is infrequent. Weather conditions probably would not pose navigational or mooring hazards. Coastal ship traffic is relatively light.

Oceanic biology

The immediate area is of relatively low biologic importance when compared to the highly productive areas off Estero and Monterey bays and the Channel Islands. The tanker route from Point Conception to Camp Pendleton probably would be located west of the Channel Islands, as would potential oil spills. Oil spills from this tanker route could impact all of the Channel Islands and the unique and productive Cortes and Tanner banks. Impacts potentially are very severe, but predicted occurrences of oil spills are low. More complete descriptions of these areas and possible impacts are presented in Sections 2.1.7.1 and 2.1.8.1 (descriptions of marine vegetation and

wildlife), and in Sections 3.1.7.1 and 3.1.8.1 (impacts on marine vegetation and wildlife).

Coastal biology

The Camp Pendleton coast is mostly comprised of sandy beaches or bluffs. Sensitive areas along the coast include: the San Mateo kelp bed, 3 miles north of San Onofre; Barn kelp bed, 6 miles south of San Onofre and north of the proposed mooring; a small kelp bed offshore of Las Flores Marsh; and the Santa Margarita Marsh, an estuary at the mouth of the Santa Margarita River. The first two are stable kelp beds that in the past were harvested commercially. Santa Margarita Marsh is an area of potential biotic significance. The area was once an anadromous stream, providing an area for steelhead migration and spawning. Three Endangered species of birds have been cited as being in the area: the least tern, the brown pelican, and Belding's Savannah sparrow. Two other sensitive areas along the coast include Dana Point and Doheny Beach marine life refuges, located approximately 5 miles north of San Clemente.

Impacts of oil spills generally would be moderate. Offshore spills would probably be driven onto the beaches and/or into the marshes. Impacts to the kelp beds, marine life refuges, and the Santa Margarita Marsh could be very severe.

Air quality

The poor ventilating capacity of these sites is comparable to other sites in California (Section 8.2.5.1). Even though local emissions are relatively low, the Federal oxidant standards were exceeded an average of 130 days each year between 1973 and 1975 (FEA, 1976). Most of the oxidant probably originated in the Los Angeles Air Shed. A lightering operaton off Camp Pendleton contributes hydrocarbon vapors and nitrogen oxidants to local

oxidant production. There is marginal evidence of the California one-hour nitrogen dioxide standard (0.25 ppm) being exceeded.

Emissions from older tankers with insufficient segregated ballast would contribute to additional exceeding of oxidant standards. With mitigating measures as effective as those committed at Long Beach, the adverse impacts would be similarly small. Additional facilities would be necessary to provide tankers with low-sulfur fuel. If the facilities were provided, the impact resulting from sulfur oxides would be slightly smaller than at Long Beach owing to remoteness of the monobuoys from shore. It is unlikely that the project would cause violation of nitrogen or sulfur oxides or particulate standards. There would be a general adverse air quality impact owing to the greater length of the tanker route required by this alternative terminal site. Air quality degradation resulting from this site would impact population and recreational resources.

Geology

The Camp Pendleton area is within shaking distance of two major faults: the Elsinore and the Newport-Inglewood. Bedrock acceleration from the 50-year earthquake is estimated to range from 0.2 to 0.4 g. Information is lacking on the liquefaction potential and landslide potential.

The southern California coast is characterized by an upper layer of semiconsolidated sediments of marine origin and unconsolidated materials in alluvial river valleys. The seismicity could pose some potential problems.

Terrestrial biology

The Camp Pendleton area is an unusual ecological resource. The military base has effectively prevented urbanization along approximately 15 miles of the coast. The northern hillsides still support a native chaparral vegetation which in turn forms an important wildlife habitat. Other coastal

vegetation includes open grazing grasslands, common coastal sage scrub, and riparian zones in the drainages of Las Flores Creek and the Santa Margarita River.

Onshore storage/surge facilities would have only a minimal effect on the vegetation and wildlife. Only small areas of the valuable resources would be damaged or destroyed. However, ancillary development, especially residential urban growth, could have very severe impacts, possibly destroying these valuable ecological habitats.

Land use

Only minor land-use impacts would occur in terms of conflicts with present uses. The principal conflicts would arise between the possible public use of the Camp Pendleton area and its beaches, and the onshore facilities.

Visual and recreational resources. Camp Pendleton is a largely open-space area along the southern California coast between the urbanized Orange County coast and urbanized San Diego area. Development of an onshore port terminal tank farm within the coastal zone would conflict with visual quality guidelines in the California Coastal Plan and would constitute an industrial intrusion on this largely open-space reach of the southern California coast. Much of the coastline of Camp Pendleton will be opened to public recreational use under a lease by California State Beaches and Parks. Hence, chronic oil spills associated with monobuoy operations could wash ashore on public beaches.

Socioeconomics

The nearest community to the Camp Pendleton site is San Clemente, population 17,000. The small city does not have an industrial/labor infrastructure. However, the site is located less than 40 miles from Los Angeles to the north and San Diego to the south. Both cities have large urban populations

and are capable of providing workers and services sufficient to supply and maintain an oil terminal off Camp Pendleton. Changes in the structure of nearby communities might occur, especially if ancillary development led to large urban growth. Overall, the socioeconomic impacts would be low to moderate.

8.2.8.2 Camp Pendleton to Midland pipeline corridor

The proposed corridor would originate on the coastal drainage plain near Las Pulgas Canyon in Camp Pendleton, California, and then traverse the Santa Margarita and Las Flores mountains. After crossing this highly valued habitat area, the route would parallel an existing railroad transportation corridor to the community of Fallbrook, an important south coast agricultural area. Upon leaving Fallbrook the corridor would parallel existing transportation corridors through the Gavilan Mountain pass and through French Valley to near the community of Hemet. Continuing west of San Jacinto, the corridor would cross the San Jacinto Valley, and connect with the Southern California Gas Company existing gas pipeline near Beaumont.

Terrestrial biology

The route for this alternative would be through the coastal sage scrub of Las Pulgas Canyon and the California grasslands. Much of the land in the area has been cleared for the planting of extensive avocado groves. Eastward, a community of California grassland, dominated by exotic grasses, exists along with a chaparral community consisting primarily of chamisa, manzanita and California lilac. The remainder of the route to Beaumont would consist primarily of farmland devoted to the production of wheat. Plant and animal communities eastward to Midland, Texas, are identical to those of the proposed project.

Geology

The geological setting for this alternative would present a similar seismic percentage profile to the Long Beach alternative. Twenty-two percent of the routing occurs in Seismic Risk Zone 3, 56 percent of the route is in Seismic Risk Zone 2, with the remaining distance (22 percent) in Seismic Risk Zone 1.

Most of the routing occurs through soils classified as aridisols (73 percent) which are subject to erosion. Entisols are encountered approximately 7 percent of the time, indicative of the rocky areas that would be crossed. The 993-mile routing from Camp Pendleton to Midland is similar in topography to the proposed route from Long Beach.

Land use

Approximately 12 miles of the area through which this pipeline alternative would pass is in the military reserve of Camp Pendleton in San Diego County. This area is used by the U.S. Marines, primarily for maneuvers, but some land is leased for grazing. The route would extend into Riverside County, passing northwest of Hemet to converge near Beaumont with the proposed route to Midland. Land uses between Camp Pendleton and Beaumont are largely farming and grazing.

Visual and recreational resources. The pipeline would encounter high scenic values in the Las Pulgas Canyon area, but the resultant scars would not be seen by much of the general public as the route traverses Camp Pendleton which, except for the coastline, is closed to general public use. Much of the remainder of the corridor follows existing pipeline scars and hence would have relatively minor impacts compared to a new construction corridor removed from existing rights-of-way.

8.2.9 Trans-Guatemala pipeline

The alternative of a pipeline across Guatemala has not been analyzed beyond the level of detail presented in Section 8.0.2 (Alternative 9) because of lack of available environmental data.

8.3 RAIL TRANSPORT ALTERNATIVE

There will be a time lag between the flow of crude oil through the Trans-Alaska Pipeline and the construction of a pipeline to eastern markets. One of the immediate options to accommodate this flow of crude oil is the use of unit trains from West Coast terminals to the Midwest.

Historically, transporting large quantities of crude oil by railroad tank cars has not been economically acceptable to the oil companies. Railroads currently carry less than 1 percent of all crude oil transported in the United States.

A unit train consists of 90 to 95 tank cars operated as one unit and capable of carrying approximately 50,000 barrels of oil. The tank cars are connected with flexible hoses which permit loading and unloading of the cars in strings at approximately 70 barrels per minute. Spillage of oil and the collection and disposal of air pollutant vapors has been adequately curtailed.

While the railroad system throughout the western states can adequately handle the West Coast surplus of crude oil, it is doubtful if enough tank cars could be built in time for transshipment of 500,000 bbl/d.

Several unit train alternatives are currently being explored by the industry. The most advanced appears to be a proposal by General American Transportation Corporation (GATX), Burlington Northern Railroad, and Exxon to move 30,000 bbl/d between Portland, Oregon, and Cutbank, Montana. There

are other plans using the Burlington Northern route to ship oil to the Portal pipeline at Minot, North Dakota, and to transport 200,000 bbl/d between Long Beach, California, and Midland, Texas. Port Westward, Oregon, also is being considered as a possible terminal facility. This port now has facilities for docking 35,000 DWT tankers.

The potential environmental impacts at Port Westward are numerous. Potential for damage to critical resources by oil spills is high. Containment of oil spills is made very difficult by the strong tidal flows up the Columbia River and by the eddying activity at the mouth of the Columbia.

Shipping crude oil in 35,000 DWT tankers would require many more ships and unloadings than proposed at Long Beach. Substantial dredging would be required to accommodate larger tankers, and the resulting impacts on local biotic communities, recreational resources, and land uses would be great.

The facilities at Port Westward could load up to 300,000 barrels of oil daily (six 95-car trains) directly from 35,000 DWT tankers. Each train could be loaded in six hours by two men. The system could be designed to capture and hold all vapors from contact with the atmosphere and to minimize oil spills. Burlington Northern has proposed Anacortes, Washington, as an alternative marine terminal site. Use of Anacortes is, of course, subject to future tanker regulations in the Puget Sound area. Impacts at this port would be similar to those discussed previously for the Cherry Point alternative port.

From Port Westward (or alternative site), the unit trains would move to Cutbank, Montana, and Minot, North Dakota. At Cutbank, they could discharge into the Glacier pipeline which has a capacity of 88,000 bbl/d. This pipeline serves three refineries at Billings, Montana.

At Minot, the trains could off-load into the Portal pipeline (capacity 100,000 bbl/d) and the Amoco pipeline (up to 51,000 bbl/d). There also exists the possibility that the trains could go on to Clearbrook, Minnesota, to off-load into the Minnesota pipeline (capacity 190,000 bbl/d) or the Lakehead line (capacity 1,555,000 bbl/d).

Table 8.3.1-1 shows the requirements for railroad tank cars that would be generated by the need to move varying quantities of oil.

Table 8.3.1-1

Tank Cars Needed for Unit Train Operations,

Port Westward, Oregon, to Minot, North Dakota

BARRELS PER DAY	Number of Trains	Number of Cars
50,000	5	475
100,000	10	950
150,000	15	1,425
200,000	20	1,900
300,000	30	2,850

Northern refiners have two other options for movement of crude into their refineries:

1. Mississippi River barges from Gulf Coast ports to St. Paul. This option is available for a certainty only seven months of the year, as the northern river route can be frozen for five months.

2. Product pipelines which could be used to move crude on a "when-available" basis from the South and Southwest.

Neither of these options appears to offer an uninterrupted, reliable flow of crude oil. In fact, Montana and North Dakota refineries would remain cut off from crude supplies under these options. Unit train deliveries could be compatible with either of the options.

One other element which could affect the use of unit trains would be crude exchanges with Canada. Implementation of a Canadian exchange program would not appear to make unit trains feasible.

8.4 ALTERNATIVE OF ALL NEW PIPELINE CONSTRUCTION IN PROPOSED CORRIDOR

Abandonment of either the Southern California Gas Company pipeline or the El Paso Natural Gas Company pipeline, or both, for subsequent conversion to crude oil use might or might not be permitted by either the Public Utilities Commission of California (Southern California Gas Company pipeline) or the Federal Power Commission (El Paso Natural Gas Company pipeline). An alternative would then be the construction of a new pipeline in the same corridor. The right-of-way for the existing natural gas pipelines would be expected to be utilized or closely paralleled. It might be necessary to detour around existing urbanized areas such as Beaumont and Banning where encroaching development constrains acquisition of new rights-of-way adjacent to the existing ones. Other detours from the existing right-of-way to avoid steep topography in the Dome Rock, Winchester, and Delaware mountains are possible. Additionally, a new pipeline might have to detour around, rather than traverse, the Kofa Game Range.

It is expected that a line larger than 30 inches would be used in the all-new construction alternative. A 42-inch pipe could move 500,000 bbl/d at minimal levels of pump installation, and could be powered to move 1 million bbl/d at maximum; it would thus correspond to the proposed project plus its possible second phase which has been discussed in Chapter 1. The location, number, and horsepower

requirements of pump statons would probably change as a result of new pipeline hydraulics.

Information concerning the route, assuming it stays within the gas pipeline corridor, its environmental sensitivity, and many of its expected impacts has been presented under the applicant's proposal in the main body of this report. Modifying the project to use all new pipeline would affect those impacts referenced previously in two basic ways: (1) the long corridor of old construction scar now existing above the gas pipelines would once again be disrupted by equipment access and construction, with loss of the amount of natural regrowth that has occurred, and (2) there would be no reduction in gas pipeline capacity presently serving California. The impacts of continuation of new pipeline within the existing right-of-way within the Kofa Game Range to Eagletail Mountains, described in Chapter 3, would be extended over the entire length of the existing natural gas pipelines. New pump station sites would have impacts analogous to the proposed pump station site, but would be different in site specifics. The new pipeline would be able to move Elk Hills crude oil if needed. A revision of the present ES in terms of Chapters 1 and 3 through 7 would be required, with revision of Chapter 2 as well, if significant detours for the existing right-of-way were proposed.

REFERENCES

Chapter 8

1. Little, A.D. 1976. SOHIO West Coast to Mid-Continent Pipeline Project. Draft Environmental Impact Report. Vol. 3, Part 2. Prepared for the Port of Long Beach and the California Public Utilities Commission.

2. Federal Energy Administration. 1976. North Slope Crude, Where To? -- How? An Analysis of the Alternatives Available for the Transportation and Disposition of Alaskan North Slope Crude. Draft Report. Washington, D.C.

3. Standard Oil Company of California. 1974. Estero Bay Deepwater Terminal and Estero Bay/Richmond Pipeline Project, Draft Environmental Impact Report. Standard Oil Company of California, Corp. Eng. Dept., San Francisco, CA.

4. U.S. Army Corps of Engineers. 1973. West Coast Deepwater Port Facilities Study. U.S. Army Corps of Engineers, North and South Pacific Div., Portland, Oregon and San Francisco, CA.

5. U.S. Department of the Interior. U.S. Geological Survey. A Probabilistic Estimate of Maximum Acceleration in Rock in the Contiguous United States. Open File Report 76-416.

6. Williams Brothers Environmental Services. 1976. Environmental Impact Assessment of the West Coast/Mid-Continent Pipeline Project. Prepared for SOHIO Transportation Company, Tulsa, OK.

GLOSSARY

abiotic -- refers to the nonliving elements of the environment.

advection -- the horizontal movement of a mass of air that causes changes in temperature or in other physical properties of the air.

aerobic -- living or active only in the presence of free oxygen.

aerosols -- wet or dry small particles in the atmosphere. Also called "particulate matter."

air quality standard -- any state or national ambient air quality standard (NAAQS), as specified ambient concentration for a specified air pollutant not to be equalled or exceeded either more than once per year, or not at all. Each standard is based on measurements averaged over a given time period.

air quality standards, primary -- national primary standards are meant to protect the health of most people with a margin of safety.

air quality standards, secondary -- national secondary standards are meant to protect property and other human welfare values, such as aesthetics.

ambient -- encompassing atmosphere or body of water.

anaerobic -- living, active, or occurring in the absence of free oxygen.

anode -- The positive electrode of a cathodic protection system designed to inhibit external corrosion on buried structures such as pipelines. The anode is buried at a position in the earth located to distribute electric current from the anode through the soil and into the structure being protected.

ANSI -- American National Standards Institute.

API -- American Petroleum Institute.

anticyclone -- a system of winds that rotates about a center of high atmospheric pressure clockwise in the Northern and counterclockwise in the Southern hemispheres.

AQCR -- Air Quality Control Region. The United States is divided into AQCRs for designating jurisdictional boundaries in measuring and maintaining air quality.

AQMA -- Air Quality Maintenance Area. A region in violation or in danger of coming into violation of a National Ambient Air Quality Standard (NAAQS).

AQMP -- Air Quality Maintenance Plan. A schedule of procedures and regulations to maintain or improve regional air quality.

AQMTF -- Air Quality Maintenance Task Force; a liaison of state and local agencies.

ARB -- Air Resources Board; the California agency charged with air quality management.

arborescent -- treelike in size and habit of growth.

aromatic -- characterized by the presence of at least one benzene ring; describes cyclic hydrocarbons and their derivatives.

arroyo -- a stream channel or gully in arid country, usually with steep banks, dry much of the time.

ARTSIM -- acronym of Environmental Research and Technology, Inc. for their version of the DIFKIN photochemical diffusion model which is used to compute oxidant and other air pollutants from emissions rates and meteorological factors.

ASME -- American Society of Mechanical Engineers.

ASTM -- American Society for Testing Materials.

AUM -- animal unit month; a measure of forage or feed requirement to maintain one animal for 30 days.

average -- as a measure, the sum of the measurements divided by the number of measurements.

average, one-hour -- the average for measurements made in a one-hour period. Other averages for 3 hours, 24 hours, and one year are used in air quality monitoring.

avifauna -- birds.

axenic -- a pure culture; having no other kind of organism present.

azoic -- having no life; relating to the part of geologic time before life.

APCD -- Air Pollution Control Board. California districts charged with regulation of regional air quality. Control of stationary source performance is normally delegated by EPA and CARB.

backfill -- earth that is replaced after a construction excavation.

backhoe -- a self-propelled machine with an arm equipped with a toothed shovel that scoops earth as the shovel is pulled toward the machine.

bajada -- a broad alluvial slope extending from the base of a mountain range out into a basin; it is formed by coalescence of separate alluvial fans.

ballast -- a heavy substance, such as seawater, used in a ship to improve stability and controllability, especially after discharge of cargo.

ballasting -- the process of taking on ballast, such as seawater, in an oil tanker, to immerse the hull, propeller, and rudder in the interest of controllability and to improve stability of the ship. Depending on the type of ship, ballast is put into cargo tanks or separate compartments, which results in the displacement of vapors, including hydrocarbons, into the atmosphere.

barrel -- a unit of volume measure for crude oil and liquid products equal to 42 U.S. gallons.

baseline -- air quality, water quality, or meteorological data used as a starting point in estimating the impacts of new emissions.

bathypelagic -- relating to or living in the sea beyond the neritic or continental shelf region or zone.

bell hole -- an excavation dug beneath a pipeline to provide room for the use of tools by workers.

benthic -- relating to or occurring at the bottom of a body of water, especially in the depths of the ocean.

benthos -- the bottom of the sea, especially in the deep parts of the ocean; also, animals and plants living on or in the bottom of bodies of water.

bilge oil -- waste oil which accumulates in the lower spaces in a ship; usually mixed with larger quantities of water.

biomass -- the amount of living matter (as a unit area of volume of habitat).

biome -- a major biotic community composed of all the plants and animals and communities, including the successional stages of an area.

biota -- all of the species of plants and animals occurring within a certain area or region.

blind flange -- a solid plate with bolt holes around the periphery bolted to an open end to seal off a section of pipe.

block valve -- a valve which can be closed to isolate one section of pipe from the adjacent section.

blowout -- a bursting of a container caused by the weight or pressure of the contained material (e.g., oil in the hold of a tanker); also refers to an excavation in loose soil, usually sand, produced by wind.

BOD -- biological oxygen demand.

brake horsepower (BHP) -- a unit of power developed by an engine or electric motor as measured at the drive shaft; the actual or delivered horsepower.

breasting or mooring dolphin -- a buoy or spar used in mooring ships.

BS&W -- Basic Sediment and Water, usually found in crude oil.

Btu -- British thermal unit; a measurement of energy derived from burning hydrocarbon fuels.

bunker fuel oil -- a fuel oil used in ships' boilers and large heating and generating plants.

bunkering -- the loading of bunker fuel on board ship. Vapor within the fuel tanks is released to the atmosphere when displaced by incoming bunker fuel.

butterfly valve -- a type of valve which is opened and closed by a disc that pivots on a shaft in the throat of the valve.

calendar day capacity -- the number of barrels each day a refinery unit yields on the average, including down time used for turnarounds.

CARB -- California Air Resources Board (see ARB).

carnivore -- flesh-eating animal.

cathodic protection -- an anticorrosion technique for metal installations; pipelines, tanks, buildings in which weak electric currents are established to offset the current associated with metal corrosion.

cathodic protection rectifier -- the rectifier converts alternating current power supply into direct current output. This output is connected to a buried anode which produces an electrical current through the soil and into the pipeline, which is thus placed under cathodic protection.

centrifugal pump -- a pump made with blades or impellers in a close-fitting case. The liquid is pushed forward by the impellers as they rotate at high speed. Centrifugal pumps, because of their high speed, are capable of handling large volumes of liquid.

cf/d -- cubic feet per day.

cfm -- cubic feet per minute.

cfs -- cubic feet per second.

cf/yr -- cubic feet per year; applied as a measurement of natural gas.

check valve -- a valve with a free-swinging tongue or clapper that permits liquid to flow in one direction only, as in a pipeline.

climax -- a type of plant or animal community which is more or less in stable equilibrium with existing natural environmental conditions.

closed loop control -- when referring to computers, a term meaning complete control is vested in the computer.

CO -- carbon monoxide

coating and wrapping -- a field operation for preparing a pipeline to be lowered into the ditch. The line is coated with an inert material, then spiral wrapped with a tough, chemically impregnated paper. Machines ride the pipe and coat and wrap in one continuous operation. This process protects the pipeline from corrosion. For large pipeline jobs, the pipe may be coated and wrapped at a mill or construction yard site, and any breaks in the coating corrected when the pipe is installed.

concentration -- the relative content of a component (as dissolved or dispersed material) and measured by weight or volume of material per unit of volume of the medium.

concentration, average -- the average of a series of measurements of concentration.

concentration, maximum -- the highest individual or average measurement of concentration.

constant per capita income -- the growth in per capita income after controlling for the effects of inflation.

conterminous -- having a common boundary; the 48 United States.

continental shelf -- the shallow submarine plain of varying width forming a border to a continent and typically ending in a steep slope to the ocean depths (often arbitrarily defined as not exceeding 200 meters depth).

continental slope -- the part of the continental margin beyond the continental shelf where the sea bottom slopes steeply to the ocean floor (abyss).

control panel -- an assembly of indicators and recording instruments; pressure gauges, warning lamps, and other visual or audible signals for monitoring and controlling a system.

copepod -- minute freshwater and marine crustacean.

crude runs -- the amount of crude oil refined through crude oil distillation; usually presented on a per day basis.

cyclones -- a system of winds that rotates about a center of low atmospheric pressure counterclockwise in the Northern and clockwise in the Southern hemispheres. Often associated with moderate storms outside the tropics.

deadweight tonnage -- (see DWT).

decibel (dB) -- a logarithmic unit which measures the pressure levels of sounds.

decibel-A (dBA) -- a decibel unit which is modified to better represent the relative insensitivity of the human ear to low-pitched sounds.

demersal -- bottom-dwelling; e.g., marine organisms.

depuration -- process of purifying or cleansing.

desert pavement -- a nearly flat soil surface consisting of a single closely packed layer of pebbles which are covered with dark brown varnish.

detritus -- organic debris from decomposing plants and animals.

diatoms -- microscopic one-celled plants.

diffusion model -- a model, calculated by formula, graphs, or computer, which estimates the dilution of an air pollutant as it is carried downwind. The models are based on physical principles with various simplification to aid solvability.

dinoflagellates -- a group of single-cell organisms that possess characteristics of both plants and animals. Like plants, they can manufacture food through photosynthesis; they can also move about like animals.

dispatcher -- an employee responsible for scheduling and controlling movement of oil through pipelines.

DWT -- deadweight tonnage. The total weight capacity of a ship expressed in long tons (2,240 lbs). Displacement of a fully loaded ship, less the weight of the ship itself.

ecotone -- a transition area between two adjacent ecological communities (as forest and grassland), usually exhibiting organisms common to both as well as having characteristics of its own.

emission -- unwanted substances released by human activity into air or water.

emission, primary -- an emission which is treated as inert.

emission, secondary -- unwanted substances which are chemical byproducts of reactive emissions.

endemic -- restricted to or native to a particular area or region.

epifauna -- organisms living on the surface of the ocean bottom, sometimes specifically on the surface of firm substrate or bottom.

epipelagic -- relating to that part of the seas into which enough light penetrates for photosynthesis to take place.

epiphytes -- nonparasitic plants using other plants or nonliving objects for support.

epithelial -- relating to a membranous tissue that covers a surface or lines a tube or cavity of an animal body and serves especially to protect the other parts of the body and produce secretions and excretions.

ERT ARTSIM model -- A computer system which simulates the diffusion and evolution of reactive air pollutants. The system simulates moving (Lagrangian) parcels of air and was developed from an earlier version called DIFKIN.

estuary -- an arm of the sea at the mouth of a river, in which the current of the river meets the tide.

euphausiids -- small crustaceans resembling shrimps, often forming an important part of marine plankton.

euphotic -- relating to the area near sea surface with sufficient light penetration for active photosynthesis.

euryhaline -- able to live in waters of a wide range of salinity.

eurythermal -- able to tolerate a wide range of temperatures.

eutrophication -- "aging"; the process by which a body of water becomes more eutrophic; i.e., rich in dissolved nutrients and often deficient in oxygen.

fault -- a fracture or zone of fractures in rock strata which have undergone movement that displaces the sides relative to each other, usually in a direction parallel to the fracture. Abrupt movement on faults is a cause of most earthquakes.

fauna -- animals or animal life.

fecundity -- fertility; fruitfulness in producing offspring or vegetation.

finder -- a device designed to safely absorb the impact of a ship upon contact with a fixed structure such as a berth or pier.

fire wall -- a dike built around an oil tank to contain the oil in the event the tank ruptures or catches fire. A wall constructed to isolate one area from an adjacent area.

fjord -- a long narrow inlet of the sea; usually represents the seaward end of a deeply excavated glacial trough.

flagellates -- one-celled organisms possessing a flagella (whip-like appendage).

flange -- a type of pipe coupling made in two halves. Each half is screwed or welded to a length of pipe and the two halves are then bolted together joining the two lengths of pipe.

floating roof -- a roof that rests on the surface of the oil contained in a tank rather than on a structural member. The roof raises and lowers with the level of liquid within the tank.

flocculated -- small, loosely aggregated lumps or loose clusters.

flora -- plants or plant life.

floristic -- relating to vegetation with respect to the component species, their geographic distributuion, relative abundance, etc.

fluviatile (fluvial) -- of or living in rivers.

front -- in climatology, the boundary between two dissimilar air masses.

fugitive dust -- airborne pulverized soil particles.

g -- gram.

gate valve -- a pipeline valve made with a wedge-shaped disc that is moved from an open to closed position by action of a threaded valve stem.

gas freeing -- the deliberate replacement of the atmosphere within an empty oil cargo tank by fresh air to allow entry for inspection or repairs. To reach the gas-free stage, the tank must be cleaned and the atmosphere must be changed a sufficient number of times to ensure that no explosive or toxic conditions exist.

gpm -- gallons per minute.

gravity -- The force which attracts matter towards the center of the earth and gives it weight.

grout -- a concrete mixture used to fill in around caissons, heavy machinery beds, and foundation work.

gyre -- a circular or spiral motion of a water mass.

halocline -- salinity gradient (ocean).

HC -- hydrocarbons; a mixture of hydrocarbon compounds usually referred to in the vapor state.

header -- a large diameter pipe into which a number of smaller pipes are perpendicularly welded or screwed; a collection point for various liquid gathering lines.

herbivore -- plant-eating animal.

high -- in climatology, an air mass characterized by higher atmospheric barometric pressure than surrounding air masses.

HMW -- high molecular weight.

hopper dredge -- dredger which can act as its own hopper and can thus transport the mud it picks up and dump it at a designated site.

hoteling -- a ship at anchor or at berth, and consuming fuel only for electrical power generation.

horsepower -- a unit of power equivalent to 33,000 foot-pounds per minute or 745.7 watts of electricity.

hydraulic head or static head -- pressure exerted by a column of fluid. It is usually expressed in feet or inches of water or other liquid. It may be converted to pounds per square inch.

hydrocarbons -- compounds composed principally of carbon and hydrogen; they occur in petroleum, natural gas, coal, and bitumens.

hydrocarbons, nonmethane -- mixture or concentration of hydrocarbons with the methane fraction ignored. One of many formulations for reactive hydrocarbons.

hydrocarbons, reactive -- mixture or concentration of hydrocarbons with faction assumed to be nonreactive removed from consideration.

hydrostatic testing -- filling a pipeline or tank with water under pressure to test for tensile strength; its ability to hold pressure without rupturing.

hygroscopic -- capable of taking up and retaining moisture.

ID -- inside diameter of pipe; used in specifing pipe size.

inerting -- the introduction of inert gas into the space above crude oil to reduce the oxygen level in an oil tanker's cargo compartments to prevent corrosion and explosion. The gas used is usually flue gas from the ships boilers and washed clean of sulfur and other corrosive substances.

infauna -- organisms living within or underneath the ocean bottom; sometimes, specifically within or on a soft bottom.

inhibitor -- a chemical used to inhibit or retard internal corrosion of pipelines.

intertidal -- relating to or part of the littoral or coastal bottom sea zone between low and high tide marks.

inventory, emission -- a list of daily or annual emissions, listed by pollution source category (e.g., trains, refineries, etc.).

inversion, temperature -- a stable atmospheric layer, in which temperature increases with height; the layer strongly resists vertical motion.

invertebrates -- the large group of animals lacking a spinal column, including sponges, worms, insects, crustaceans.

JTU -- Jackson turbidity units; a measure of "muddiness" in water.

kelp bed -- generally used to include all the seaweed species occurring in association with several types of giant kelps.

Kg/hr -- kilogram per hour. A unit for rate of emission of an air pollutant.

knot -- speed in units of 1 nautical mile per hour or about 1.15 miles per hour.

lacustrine -- of or living in lakes.

Langley/min -- a unit of solar radiation equivalent to 1 gram calorie per square centimeter of irradiated surface.

larids -- family of sea birds including gulls and kittiwakes.

larvae -- the preadult forms in which some animals hatch from the egg; often, as in marine invertebrates, larvae are quite different from adult forms.

lightering -- off-loading or loading ships (e.g., crude oil) not lying at wharves, using boats or barges.

lineup clamps -- a device that folds the ends of two joints of pipe together in precise alignment for welding.

liquefaction -- the process of making or becoming liquid (soils).

littoral -- relating to or inhabiting the bottom of the sea nearshore, roughly within a depth to which light and wave action reach; usually taken as between the high tide mark and 200 meters depth.

LMW -- low molecular weight.

LNG -- liquid natural gas.

load factor -- a measure of utilization of an electric generating system capacity, usually expressed in percentage.

low -- in climatology, an air mass characterized by lower atmospheric barometric pressure than surrounding air masses.

Lower 48 -- Continental United States.

LTPCD -- long tons per calendar day.

m -- meter.

macrofauna -- animals too large to pass through a 1.0 mm screen.

macrophyte -- plants having large or elongated leaves usually with many veins, usually aquatic or riparian.

manifold -- an area where pipelines entering and leaving a pump station or terminal converge and where all valves for controlling the incoming and outgoing streams are contained.

master control unit -- a control center, usually at the terminal, from which a pipeline is monitored by microwave devices to ensure correct flow within a pipeline as well as the integrity of protective devices along a pipeline.

Mbbl/cd -- thousands of barrels per calendar day.

Mbbl/sd -- thousands of barrels per stream day.

meiofauna -- animals which can pass through a 1.0 mm screen but not through a 0.1 mm screen.

mesopelagic -- relating to the ocean zone below the layer of significant light penetration and above the benthic zone.

MHHW -- mean higher high water; average height of the higher high waters over a 19-year period. For shorter periods of observation, corrections are applied to eliminate known variations and reduce the result to the equivalent of the mean 19-year value.

MHW -- mean high water; the average height of the high waters over a 19-year period. For shorter periods of observation, corrections are applied to eliminate known variations and reduce the results to the equivalent of a mean 19-year value. All high water heights are included in the average where the type of tide is either semidiurnal or mixed. Only the higher high water heights are included in the average where the type of tide is diurnal. So determined, mean high water in the latter case is the same as mean higher high water.

microfauna -- animals which can pass through a 0.1 mm screen.

micron -- one millionth of a meter.

micronekton -- microscopic animals which swim in the sea.

microwave -- radio communications which are of sufficiently short wavelength (or high frequency) as to be focused on a line-of-sight between sending and receiving equipment. These radio signals carry information for control purposes.

milieu -- environmental setting.

mixing height -- the distance from the ground to a daytime (temperature) inversion layer.

MLLW -- mean lower low water; the average height of the lower low waters over a 19-year period. For shorter periods of observation, corrections are applied to eliminate known variations and reduce the results to the equivalent of a mean 19-year value. Frequently abbreviated to lower low water.

MLW -- mean low water; the average height of the low waters over a 19-year period. For shorter periods of observations, corrections are applied to eliminate known variations and reduce the results to the equivalent of a mean 19-year value. All low water heights are included in the average where the type of tide is either semidiurnal or mixed. Only the lower low water heights are included in the average where the type of tide is diurnal. So determined, mean low water in the latter case is the same as mean lower low water.

MMbbl/d -- million barrels per day.

MMbbl/cd -- million barrels per calendar day

monitoring station -- a mobile or fixed site equipped to measure instantaneous or average ambient air pollutant concentrations.

moraine -- accumulation of rock material by a glacier; occurs in various topographic forms such as ridges or more level areas according to the manner of formation.

mosaic -- a pattern of vegetation in which two or more kinds of communities are interspersed in patches; e.g., clumps of shrubs with grassland between.

motile -- exhibiting or capable of movement.

mucilaginous -- relating to a gelatinous substance that is obtained from the seed coats of various plants.

mysids -- members of a family of small crustaceans resembling shrimps.

NAAQS -- National Ambient Air Quality Standard(s). Nationally specified ambient concentrations for various air pollutants not to be exceeded more than once a year. Each standard is specified for a given averaging time period.

nauplii -- crustacean larvae.

nekton -- swimming animals of the sea, in contrast to organisms living on the bottom (benthos) or floating near the surface (plankton).

neritic -- relating to the belt or region of shallow water adjoining the seacoast.

neuston -- minute organisms which float in the surface film of water.

nitrate -- any compound containing a subgroup of one nitrogen and three oxygen atoms. In atmospheres, a principal source is nitrogen dioxide.

nitric oxide -- a molecule of one nitrogen and one oxygen atom -- NO. Results usually from combustion of organic substances containing nitrogen and from recombination of nitrogen decomposed in air during high temperature combustion.

nitrogen dioxide -- a molecule of one nitrogen and two oxygen atoms -- NO^2 Results usually from further oxidation of nitric oxide (NO) in the atmosphere.

NO -- nitric oxide.

noise level, median -- the level of noise exceeded 50 percent of the time. Usually specified as either the daytime or the nighttime median noise level.

NOx -- oxides of nitrogen, a mixture of NO and NO_2.

NO_2 -- nitrogen dioxide.

oceanic -- the open sea as distinguished from the littoral zone (coastal bottom) or neritic waters (coastal).

OD -- outside diameter of pipe; used in specifying pipe sizes.

open loop control -- requires a decision by pipeline dispatcher rather than complete control by the computer.

ORV -- off-road vehicle; maintenance or recreational vehicle traffic disturbing natural habitat where no visible roadway exists.

OSHA -- Occupational Safety and Health Administration (Federal).

oxidant -- a mixture of chemically oxidizing compounds formed from ultraviolet stimulated reactions in atmospheres.

oxides of nitrogen -- a gaseous mixture of nitric oxide (NO) and nitrogen dioxide (NO^2) and symbolically represented as NOx. Can include particulate species such as nitrate compounds ($-NO^3$).

oxides of sulfur -- a gaseous mixture of sulfur dioxide (SO^2) and sulfur trioxide (SO^3) and symbolically represented as SOx. Can include particulate species such as sulfate compounds ($-SO^4$).

ozone -- a molecule of three oxygen atoms -- O^3. A principal component of "oxidant" in photochemically polluted atmospheres.

PADD -- Petroleum Administration for Defense District; five geographical districts in the United States which are used for petroleum analyses.

paraffin base crude -- crude oil that contains from 2 to 6 percent paraffin wax in solution, a high percentage of gasoline and kerosene, and has a relatively low specific gravity.

particulate (matter) -- pulverized matter or droplets, typically averaging one micron or smaller in diameter. Also called aerosol.

pelagic -- inhabiting the mass of seawater, in contrast to the sea bottom (benthic). Pelagic animals and plants are divided into plankton (floating) and nekton (swimming).

perennial -- a plant that lives for three or more years.

periphyton (periphytic) -- organisms that live attached to underwater surfaces.

photochemical -- one or more chemical reactions involving chemical species disassociated (split) by ultraviolet light.

photochemical diffusion model -- a diffusion model (q.v.) which includes a submodel for calculation chemical conversion of air pollutants at each time step and for each parcel of air.

photosynthesis -- in green plants the manufacture of organic compounds from water and carbon dioxide using energy absorbed by chlorophyll from sunlight.

phreatophyte -- a deep-rooted plant that obtains its water from the water table or the layer of soil just above it.

phytoplankton -- plants which float or drift passively near the surface of the sea; phytoplankton and zooplankton (animals) compose plankton.

pig (scraper) -- a cylindrical device (3 to 7 feet long) inserted in a pipeline for the purpose of sweeping the line clean of water, rust, or other foreign matter. When inserted in the line at a "scraper trap," the pressure of the oil stream behind it pushes the pig along the line. Pigs or scrapers are made with tough, pliable discs that fit the internal diameter of the pipe, thus forming a tight seal as they move along cleaning the pipe walls.

pipeline patrol -- the inspection of a pipeline for leaks, washouts, and other unusual conditions by the use of light, low-flying aircraft or

land vehicles. The pilot or driver reports by radio to ground stations on any unusual condition on the line.

pipe sling -- a stirrup-like sling made of heavy belting material used on the winch line of lifting equipment for handling, raising, and lowering of pipe.

planktivores -- organisms or animals that eat plankton.

plankton -- animals and plants which float or drift passively in the sea, mainly near the surface.

plug valve -- a type of valve constructed with a central drilled core or "plug." The valve can be opened or closed with one-quarter turn of the plug.

polymerization -- reduplication of parts in an organism.

pour point -- the lowest temperature at which liquid will pour or flow when it is chilled under specified conditions.

ppb -- parts per billion. A measure of concentration in liquids or gases.

pphm -- parts per hundred million.

ppm -- parts per million.

ppt -- parts per thousand.

pptr -- parts per trillion.

procellariids -- family of sea birds including fulmars, shearwaters, and large petrels.

products pipeline -- a pipeline carrying refined petroleum products such as gasoline or jet fuel.

protoplast -- the actively metabolizing part of a cell.

psi -- pounds per square inch.

psig -- pounds per square inch gauge (as observed on a gauge).

PUC -- (California) Public Utilities Commission.

pumping unit -- a pipeline pump and driver.

purging -- the deliberate replacement of the hydrocarbon gas mixture within an empty oil cargo tank by an inert gas to reduce the gas concentration to below the explosive mixture level. The displaced gas is released to the atmosphere.

quadrillion Btu -- equivalent to the energy drived from burning 500,000 barrels of petroleum per day for one year.

Reid Vapor Pressure (RVP) -- vapor pressure of a sample of hydrocarbons at 100°F (37.8°C).

relict -- a remnant of the population of a species that was fomerly more widespread.

relief valve -- a valve that is set to open when pressure on a liquid or gas line (or tank) reaches a predetermined level.

Reynolds number -- a dimensionless coefficient which expresses the dynamic similarity of hydraulic systems.

right-of-way (ROW) -- (1) a legal right of passage over another person's land; (2) a strip of land for which permission has been granted to build a pipeline and for normal maintenance thereafter.

riparian -- relating to or living on the bank of a river or stream.

riprap -- a foundation or sustaining wall of stones thrown together without order (as in deep water, on a soft bottom or on an embankment slope to prevent erosion).

rollback -- the approximate proportionality between emissions and air quality. In linear rollback, if emissions are halved, the ambient concentration of a pollutant, above background, is assumed to be halved.

rose wind -- in air quality analysis, a 360° circle broken into 16 equal quadrants for analyzing meteorological data.

Saybolt seconds universal -- a unit of viscosity measurement; the time in seconds for 60 milliliters of fluid to flow through a capillary tube in a vascosimeter at a given temperature.

SCADA -- Supervisory Control and Data Acquisition System; acquisition data-gathering system for the operation of the pipeline.

SCAPCD -- Southern California Air Pollution Control District.

scenario -- an account or synopsis of a projected course of action or events.

scraper trap -- a facility on a pipeline for inserting and retrieving a scraper or "pig." The trap is essentially a "breechloading" tube isolated from the pipeline by valves. The scraper is loaded into the tube like a shell into a shotgun; a hinged plug is closed behind it, and line pressure is then admitted to the tube behind the scraper. A valve is opened ahead of the scraper and it is literally pushed into the line and moved along by the oil pressure.

segregated ballast -- ballast which is contained in ship compartments designed only for that use, as opposed to pumping ballast (seawater) into empty cargo tanks.

segregated ballast, fully -- segregation of ballast is complete when tankage dedicated solely to ballasting can carry an amount of water equal, by weight, to approximately 35 percent of the ship's deadweight tonnage.

segregated ballast, 20% -- dedicated ballast tankage can hold an amount of water equal, by weight, to 20 percent of the ship's deadweight tonnage.

simulation, computer -- the modeling on a computer of many similar events, such as tanker traffic. Rules are formulated describing events, and then many events are simulated and conclusions drawn, such as frequency of queuing.

snowbirds -- retired persons who live in self-contained recreational vehicles and winter in desert areas away from snow.

SO_2 -- sulfur dioxide.

sour crude oil -- crude oil with a sulfur content greater than 1 percent; definition is dependent upon individual refinery capabilities.

South Coast Air Quality Management District -- the district charged, since February, 1977, with maintaining air quality in the Los Angeles Air Shed. Created by the California Legislature with passage of Assembly Bill 250 (1976). Supercedes the Southern California Air Pollution Control District. The Los Angeles Air Pollution Control District was previously absorbed into the latter district.

Soxhlet extraction method -- extraction of fatty or other material with a volatile solvent (as ether, alcohol or benzene) using a vertical glass cylindrical extraction tube that has both a siphon tube and a vapor tube. The cylindrical tube is fitted at its upper end to a reflux condenser and at its lower end to a flask so that the solvent may be distilled from the flask into the condenser whence it flows back into the cylindrical tube and siphons over into the flask to be distilled again.

specific gravity -- the weight per unit volume of a substance compared with the weight of the same volume of water at a given temperature. It is therefore a simple number or ratio; to determine the weight per cubic foot the specified gravity must be multiplied by 62.4 lbs per cubic feet, the density of water.

spermatophyte -- a seed-plant bearing; the trees, shrubs, grasses; the majority of existing flora.

spread -- a group of construction personnel and equipment assembled to do a major construction job; spread may be literal, as the men and equipment are strung out along the right-of-way.

State Implementation Plan -- a plan prepared by each state and subject to approval by the U.S. Environmental Protection Agency. The purpose of the plan is to achieve and maintain the National Ambient Air Quality Standards (NAAQS) through controls on emissions.

static head -- see hydraulic head.

stream day capacity -- the potential yield of a refinery unit when running at full capacity.

streamline -- the estimated trajectory of a parcel of air, as inferred from measurements taken at sites in the region.

stringing pipe -- placing joints of pipe end-to-end along a pipeline right-of-way in preparation for welding the joints together to form a pipeline.

sublittoral (benthos) -- relating to or living on the part of the coastal sea bottom below low tide mark to a depth of roughly 200 meters or the edge of the continental shelf.

substrate -- the base on which an organism lives, such as soil or the ocean bottom.

subsidence -- (1) generally a gradual settling or sinking of the ground surface usually with little or no horizontal displacement; (2) the

process of an air mass descending and resulting in heating by compression.

subtidal -- relating to or living on the part of the coastal sea bottom (benthos) below low tide mark to a depth of roughly 200 meters; sublittoral zone.

suction head (mech.) -- the height to which a pump can lift water on its suction side, measured from the free water level in the sump. Theoretically this is about 33 feet (1 atmosphere) at the freezing point, 32°F (0°C), and diminishes to 0 feet at the boiling point, 212°F (100°C).

sulfate -- any compound containing a subgroup of one sulfur and four oxygen atoms. In the atmosphere, a principal source is sulfur dioxide.

sulfur dioxide -- a molecule of one sulfur and two oxygen atoms -- SO^2. Results usually from combustion of organic substances containing sulfur.

survey stakes -- wooden markers driven into the earth by a survey crew identifying the boundaries of a right-of-way, the route of a pipeline, or a well location. Survey stakes may bear notations indicating elevation or location.

sweet crude -- definition is dependent upon individual refinery capabilities. For purposes of this report, sweet crude will mean that sulfur content is 1 percent or less.

tack weld -- spot welds temporarily joining two pieces of metal to hold them in position for complete welding.

tank cleaning -- oil cargo tanks are cleaned by a machine playing powerful jets of water or crude oil on interior surfaces in order to remove deposits, prepare for a change of cargo, or take on clean ballast. The accumulated oil and water is gathered and separated. Oil residue is discharged onshore or added on top of the next cargo load.

tank dike -- a wall of earth or concrete surrounding an oil tank to contain the oil in the event of the tank running over or rupturing.

terrestrial -- related to or living on land. Terrestrial biology deals with upland areas as opposed to shorelines or coastal habitats.

throughput -- the volume of feedstock (e.g., crude oil) processed or transported in a specifed time.

tidal prism -- volume of water flowing in and out of a harbor or estuary due solely to the tidal influence as opposed to freshwater input.

tie-in -- an operation in pipeline construction in which two sections of line are welded together.

tombolos -- a sand or gravel bar connecting an island with mainland or another island.

trajectory -- in air or water pollution analysis, the path a pollutant follows, or is assumed to follow.

translocation -- the conduction of soluble material from one part of a plant to another.

transpiration -- loss of water vapor by land plants.

trophic -- nutritional.

true vapor pressure -- the vapor pressure of a liquid at ambient temperature.

TSP -- total suspended particulates. The concentration (by weight) of all wet and dry particles suspended in the atmosphere.

turbulent flow -- fluid motion having an irregular or erratic character. Occurs when the Reynolds number is above approximately 2,400.

$\mu g/m_3$ -- millionths of a gram per cubic meter, a unit of concentration in liquids or gases.

unmanned station -- a pumping station that is started, stopped, and monitored by remote control. Through telecommunication systems, these intermediate booster stations on large trunk lines are unmanned and remotely controlled from the dispatcher's office.

venting -- the process of releasing vapors, including hydrocarbons, from tanker oil cargo tanks to the atmosphere through a valve when excessive vapor pressures develop (usually a pressure differential of 2 psi due to variations in temperature).

vertebrates -- animals with spinal columns and skulls including fish, amphibians, reptiles, birds, and mammals.

vertical can booster -- centrifugal pump with driver aboveground and vertical shaft extending below ground into a cylindrical tube or "can."

viscosity -- the term applied to a fluid indicating its resistance to shear.

visual contrast rating -- BLM's system for evaluating how well a project visually "fits" into a natural environment based on form, line, color, and texture.

visual sensitivity -- consideration of people's uses of various environments and their concerns for maintenance of scenic quality and open-space values; examples of areas of high visual sensitivity would be areas visible from scenic highways, wilderness areas, parks, recreational water bodies, etc.

VTS (VTCS) -- Vessel Traffic (Control) System. A radar and radio communication system used to space large ships in and near harbors.

zooplankton -- animals which float or drift passively in the sea usually near the surface; phytoplankton (plants) and zooplankton compose plankton.

CONVERSION

TABLE

COMMONLY USED CONVERSIONS, MEASUREMENTS, AND CALCULATIONS

Both the Metric System and the U.S. Equivalent System are used in designating units of measurement. Frequently, it is desirable to convert from one unit to another within each of these systems, as well as between the two systems.

Simplicity of conversion within the Metric System is due to its being based on the decimal system. The Metric System is widely used throughout the world, and especially within the scientific and engineering communities.

The following is not intended to be a complete compilation of units and equivalent values of the two systems. It contains only those used in this EIS.

Conversion Table

UNIT	Abbr	Metric	U.S. Equivalent
		Length	
Micromillimeter	µm	1/1,000,000 meter	0.00004 inch
Millimeter	mm	1/1,000 meter	0.04 inch
Centimeter	cm	1/100 meter	0.39 inch
Meter	m		39.37 inches
Kilometer	km	1,000 meters	0.62 mile
Mil		0.0254 millimeters	1/1,000 inch
Inch	in	2.54 centimeters	
Foot	ft	30.48 centimeters	12 inches
Yard	yd	0.914 meter	36 inches
Mile	mi	1.61 kilometers	5,280 feet
Fathom	fath.	1.83 meters	6 feet

UNIT	Abbr	Metric	U.S. Equivalent
		Length (Continued)	
Nautical mile	kn mi	1,853.25 meters	6,080.20 meters
		Area	
Square centimeter	sq cm or cm^2		0.155 square inch
Square inch	sq in or in^2	6.45 square centimeter	0.007 square foot
Square foot	sq ft or ft^2	0.093 square meter	144 square feet
Square yard	sq yd or yd^2	0.836 square	9 square feet
Square meter	sq m or m^2	10,000 square centimeters	1.195 square yards
Acre	A or a	4,047 square meters	43,560 square feet
Square mile	sq mi or mi^2	2.59 square kilometers	640 acres
Square kilometer	sq km	1,000,000 square meters	0.386 square mile
		Volume	
Cubic centimeter	cu cm or cm^3	0.000001 cubic meter	0.061 cubic inch
Cubic meter	cu m or m^3	1,000,000 cubic centimeter	1.307 cubic yards
Cubic inch	cu in or in^3	16.387 cubic centimeter	0.00058 cubic foot
Cubic foot	cu ft or ft^3	0.028 cubic meter	1,728 cubic inches
Cubic yard	cu yard or yd^3	0.765 cubic meter	27 cubic feet
Acre-foot	ac-ft	1,234 kiloliters	325,850 gallons
		Capacity	
Milliliter	ml	0.001 liter	0.061 cubic inch
Liter	l	0.001 cubic meters	0.908 quart

Conversion Table (Continued)

UNIT	Abbr	Metric	U.S. Equivalent
Fluid ounce	fl oz	29.57 milliliters	1.804 cubic inches
		Capacity (Continued)	
Pint	pt	0.473 liters	28.875 cubic inches
Quart	qt	0.946 liter	57.75 cubic inches
Gallon	gal	3.785 liters	4 quarts
Barrel	bbl	158.97 liters	42 gallons
Bushels	bu	35.238 liters	4 pecks
		Weight	
Ounce	oz	28.349 grams	0.0625 pound
Pound	lb	0.453 kilogram	16 ounces
Ton	T	0.907 metric ton	2,000 pounds
Milligram	mg	0.001 gram	0.000035 ounce
Gram	gm		0.035 ounce
kilogram	kg	1,000 grams	2.2046 pounds
Metric ton	mt	1,000 kilograms	1.10 tons
		Concentration	
To obtain Parts per million	ppm	Multiply $\mu g/m^3$ by $\frac{0.0245}{\text{(molecular weight)}}$	
To obtain Micrograms per cubic meter	$\mu g/m^3$	Multiply ppm by $\frac{\text{(molecular weight)}}{0.0245}$	
		Miscellaneous	
		(Power, Heat, Temperature, Pressure, Rate of Flow, Velocity)	
Calorie	cal	0.001 kilocalorie	0.003968 Btu
Horsepower	hp	746 watts	33,000 foot-pounds per minute
Kilowatt	kw	1,000 watts	1.34 horsepower
British thermal unit	Btu	0.252 kilocalorie	778.104 foot pounds

Conversion Table (Continued)

UNIT	Abbr	Metric	U.S. Equivalent
		Miscellaneous (Continued)	
Degree Centigrade	°C	Degree Celcius	5/9(° Fahrenheit -32)
Degree Fahrenheit	°F	1.8 degree Celius +32	
Pounds per square inch	psi	0.07031 kilograms per centimeter squared	
Barrels per hour	bbl/hr	0.159 cubic meter per hour	0.7 gallons per minute
Knot	kn	1.854 kilometers per hour	1.1515 miles per hour

APPENDICES

APPENDIX A1.0

Geotechnic Evaluation

Pipeline Route

APPENDIX A1.0

Geotechnical Evaluation of Pipeline Route

Section 1C.3.22 Existing pipeline characteristics

1.0 General

Arrangements were made to meet with representatives of El Paso Natural Gas Company and Southern California Gas Company to review the existing natural gas lines proposed for conversion to crude oil lines in Phase 1 of the project. The following report summarizes the acceptability of the line for the proposed oil service, suggests measures the applicant might take to lessen environmental impacts and identifies impacts which cannot be avoided that will adversely affect the environment.

In summary, El Paso Gas Company line 1600 and Southern California Gas Company line 2001 will operate satisfactorily in the intended pipeline service. Line 2001 will require some modification to the aboveground support. El Paso Natural Gas Company lines 1103 and 1110 may have minor weld and corrosion leaks. Hydrostatic testing of these lines will be performed to ensure their absolute integrity.

Meetings were held with Engineering and Operating personnel of these companies at their Administration, Engineering and District Operating offices where records of the lines were reviewed. Copies of the material specifications, material inspection records, construction specifications, and pipeline alignment drawings were provided. Operating records of leak experience, line maintenance and cathodic protection were reviewed.

1.1 Design

Chemical and physical properties of the existing pipe are equivalent to API 5 LX 52 except for some of the 7/16-inch and 1/2-inch wall pipe which falls in the API 5 LX 46 category. Properties were verified through a review of the original material specifications, material test and inspection records, as-built drawings and construction specifications. Materials and physical characteristics of this pipe are satisfactory for the intended oil service.

Additional pipe wall thickness, providing a factor of safety over and above that normally used for the operating conditions, has been installed in populated areas, road, rail, and river or stream crossings.

Pipe supports on the aboveground portion of the Southern California Gas Company line are designed for a pipe carrying vapors and on the basis of a .2g static horizontal seismic load.

Aboveground pipeline supports will need to be modified to provide sufficient support for a pipeline carrying liquid and to handle dynamic seismic loads for the particular region in which they are located.

1.2 Construction

Construction specifications providing for the pipe size, wall thickness, grade, method of bending, welding, pipe coating, trenching, placing, backfill, electrolysis test stations and pressure testing were reviewed for all but the 1103 and 1110 portions of the line. These specifications were complete and provided for good construction practice.

Construction inspection records are not available for the Southern California Gas Company portion of line nor the El Paso Natural Gas lines 1103 and 1110. Documentation was provided, however, on the extent of

welding X-ray. Approximately 80 percent of the El Paso Natural Gas Company line 1600 circumferential welds were X-rayed and 20 to 40 percent of the Southern California Gas Company line.

While inspection records are not available on some portions of the line, it was the practice and specified in the Construction Contracts that a company representative would be inspecting the work and be responsible for the Contractors' performance. His duties included inspection of the welder qualifications, pipe coating, trenching, placing, backfilling, electrolysis test stations and pressure testing. Pipeline alignment drawings provided show the pipe location, laterals and taps.

1.3 Coatings

Coating specifications were available for all but the 1103 and 1110 El Paso Natural Gas Company lines (approximately 88 miles). Coating consists of 3/32-inch coal tar or plasticized enamel with a 15 lb impregnated asbestos felt wrapper with special wrapping of heavier felt or fiberglass wrapping at specific locations such as road and rail crossings. Some 31 miles of the Southern California Gas Company line GWO 88807-TP are protected with an asphalt pipe coating compound.

Review of the Southern California Gas Company Annual Report -- Operating and Maintenance Studies for years 1972-1975 -- shows good bond of wrap to pipe at some 45 locations where line 2001 was exposed.

1.4 Cathodic protection

Cathodic protection has been designed and installed for the entire pipeline in conjunction with cathodic protection provided for adjacent gaslines. With the exception of lines 1103 and 1110, and some 23 miles of line 2001, lines were cathodically protected at the time they were installed. In the

cases of lines 1103 and 1110, cathodic protection has been provided as the need developed and it was some time after construction before the entire line was protected.

The cathodic protection systems receive surveillance at intervals of at least once a year and in many cases every quarter. A review of the Operating Department In-Service Reports shows adequate protection. In locations where inspection reveals the voltages have dropped below the recommended minimum, steps have been taken to follow up and correct the cause for low readings.

It should be pointed out that cathodic protection of these lines is part of an overall protection system of several adjacent lines. Should ownership of one line be transferred to SOHIO Transportation Company, it will still be necessary to continue protection in the present overall system. To properly do so requires coordinating the protection of all the lines. In this regard, it is recommended El Paso Natural Gas Company and Southern California Gas Company include the cathodic protection surveillance and maintenance of the SOHIO pipeline with that of the gas companies.

1.5 Operation and maintenance

1.5.1 Leaks and failures

The Southern California Gas Company line 2001 and the El Paso Natural Gas Company line 1600 have not experienced any leaks or failures since being placed in operation. This is not true of the 1103 and 1110 lines. Pit corrosion, stress corrosion and weld leaks have occurred in these lines.

Table A1.0-1 summarizes failures experienced in the El Paso Natural Gas Company lines from 1965 to present: It can be anticipated that lines 1103 and 1110, under the present environment and condition of the pipeline

coating, will experience continuing small corrosion and weld leaks. Two or three leaks a year in the volume of a few gallons to several barrels an hour will occur and continue until visually detected. An upgrading to the protective coating and cathodic protection would reduce this substantially. There has not been any damage or failure of any portion of either the El Paso Natural Gas Company or Southern California Gas Company portion of the line due to washouts, land slides, subsidence or earthquakes.

Section 1C.4 Pump Stations

1.0 Pumping units

This paragraph points to the low profile of the pumping units and the restriction of visibility due to natural vegetation. In an attempt to maintain this low profile a study is recommended on the transmitting of the load at a medium voltage (24 to 33 KV). The required horsepower is moderate and the lower voltage would permit transmission in less space with smaller clearances and a lower overall profile.

Table A1.0-1

Record of Fabricated Pipe Failures Found During Testing

M.P.	DATE	PIPE	MANUFACTURER	TYPE FAILURE[a]
			Line 1103	
38	1968	30-.335-X52	Consolidated	Girth weld -- O
181	1968	30-.324-X52	Republic	Manufacturing Defect -- O
228.64	1970	30-.335-X52	Republic	Longitudinal weld -- T
417.99	1973	30-.335-X52	Republic	Pit corrosion -- T
571.99	1971	30-.335-X52	Republic	Longitudinal weld -- T
577.97	1971	30-.324-X52	Consolidated	Stress corrosion -- T
580.05	1970	30-.324-X52	Republic	Pit corrosion -- O
583.56	1971	30-.324-X52	Republic	Stress corrosion -- T
			Line 1600	
195.33	1969	30-.375-X60	Republic	Longitudinal weld -- T
340.10	1969	30-.375-X60	A.O. Smith	Longitudinal weld -- T
635.15	1970	30-.375-X60	Kaiser	Longitudinal weld -- T
			Line 1110	
			No Failures on Record	

[a] O= Operation; T= Testing.

2.0 Electric power supply

Spare transformers will be available from the local power companies.

Section 1C.6 Midland Terminal

1.0 Tank spacing

Drawing 193-SK-5115 of the Midland Terminal plot plan shows a distance of 100 feet between adjacent tanks. To minimize fire exposure in these "jumbo" crude oil storage tanks, consideration is to be given to increasing the distance between them. The current issue of National Fire Protection Code No. 30 relating to tank spacing was adopted prior to the advent of tanks in excess of 200 feet in diameter. The National Fire Protection Association Committee has introduced a proposal to increase the spacing between these tanks by 1/4 the diameter of adjacent tanks where the impounding of a spill is by a dike around the tanks. The spacing of the Midland Terminal tanks would be 200 feet.

Section 1C.7 Control systems

1.0 Air conditioning

Each control building will be equipped with battery powered fans which will provide forced air cooling (using air drawn from outdoors) whenever the temperature approaches the upper temperature limit of the equipment. The dispatch center will also be alerted when the temperature rises above a predetermined alarm point.

Section 1C.8 Communication system

1.0 Communication system

The supervisory and data acquisition will continuously scan the remote terminal units. A complete scan cycle will occur in about 6 seconds. If a remote terminal fails to respond to an interogation by the master station an

alarm will be sounded in the control center. In addition, the microwave channels are monitored from a communications maintenance center in Phoenix.

2.0 Protection

The entire electrical system will be studied and designed of optimum insulation coordination. Lightning and surge problems will be minimized.

Section 1E Design criteria

1.0 Terminal facility storage tanks

The API Standard 650 Welded Steel Tanks for Oil Storage, July, 1973, as supplemented, planned for tank design is the recognized standard for materials, design, fabrication, erection and inspection of atmospheric welded storage tanks. The design only speaks to static hydraulic loads, however. This would be adequate for Midland Terminal storage, but will not suffice for the Dominguez Hills or Long Beach terminals. At this location, seismic forces need to be incorporated in the design.

Considerable effort has been expended in evaluating earthquake potential and possible seismic forces. Nothing has been provided, however, on the specific seismic loading to be used in the tank design or the method of designing for these loads.

Until recently, seismic loads were based on the Uniform Building Code, Earthquake Regulations Sec. 2314. This approach is no longer considered adequate for the type of movement and forces that might be experienced in an earthquake. A dynamic analysis incorporating the effect of wave propagation and the response of a specific tank structure to this propagation is necessary. One such treatise has been published by the National Technical Information Service, U.S. Department of Commerce, TID-7024 Nuclear Reactors

and Earthquakes, August, 1963. Chapter 6 of this publication covers an approach to dynamic pressure design on fluid containers and is frequently used in storage tank design. It points out, however, in the case of very large tanks, the period of the sloshing motion of the liquid in the tanks may be very long and beyond the range of the response spectra. A maximum period of 10 seconds is the limit of the response spectra curves in the seismic reports submitted. The period in these large tanks may exceed 30 seconds, in which case adjustments are made in the spectral values.

To properly evaluate the adequacy of the storage tanks to resist seismic forces, the design method needs to be identified along with the spectral forces used and any rationale for adjustment in these forces to compensate for the difference in actual tank period and that shown in the response spectra curves.

2.0 Storage tank spacing

Reference is made in 1E.2.9, Codes and Standards to the Oil Insurance Association OIA 631 General Recommendations for Spacing. The Midland Terminal does not meet this recommended spacing of twice the tank diameter.

Since this is a general recommendation of the insurance industry, it is not a requirement. Industry practice has been to follow the spacing shown in the National Fire Protection Code No.30. As mentioned in Section 1C6, Midland Terminal Tank Spacing of this report, spacing of large tanks in the sizes contemplated here is under review and spacing distances may be increased. There will be a maximum distance of 200 feet between tanks.

3.0 Site work

Another area of terminal design that needs consideration is the adequacy of the sewer system, both on-site and off-site, to handle the volume of fire streams used in fighting tank fires. At Long Beach, a 5,000 GPM pump as well as two 750 GPM pumps would be available to remove large quantities of oil and/or water should a fire occur. This, coupled with the volume of the catch basin and dike wall, would handle all oil and/or water for any reasonable fire-fighting period. The same pumping equipment will be installed at the Dominguez Hills Terminal.

4.0 Electrical facilities

Area classification drawings are being prepared for each facility. American Petroleum Institute recommended classification 500-C covers this subject and will be a guide for such installations.

In the pump stations 25 feet in any direction from the pump is classified as Division 2 and 50 feet in any horizontal direction for a distance of 18 inches above the ground. Any pump or trench within this 50 feet dimension is classified as Division 1.

5.0 Waste water collection

Terminal waste water treatment major equipment can be described as gravity separator, cyclone separator and coalescing pressure filter.

This equipment will allow contaminated rainwater to be treated and discharged within present Federal, state, and local water quality regulations.

Oil removed by separators or the coalescer filter will be transferred to storage tankage or directly to the pipeline.

6.0 Pipeline hydraulics

The hydraulic profile for the 500,000 bbl/cd flowing rate is reasonable. The friction losses obtained from the profile have been checked by published and unpublished methods other than that used by Williams Brothers. The independent determinations of friction losses substantially agree with those used by Williams Brothers.

7.0 Pipe wall thickness

A check of pipe wall thicknesses against the hydraulic profile for Redlands, Indio, Casa Grande and Lordsburg shows adequate thickness for the intended service based on Section 404.1.2, Straight Pipe Under Internal Pressure in ANSI B31.4-1974 where

$$t = \frac{P_i D}{2S}$$

8.0 Pipeline stresses

Considerable work has been done on the basis for seismic design of the pipeline. "Geologic-Seismic Considerations and Earthquake Design basis for the West Coast Mid-Continent Pipeline, California Segment," June, 1976 by Holmes and Narver, Inc. and Dames and Moore should be correlated with the experience of the Southern California Gas Company's 22-inch and 30-inch lines east of the Jensen Filtration Plant of the Metropolitan Water District during the Sylmar Earthquake of 9 February 1971. The three lines at this location, two 30-inch and one 22-inch, were subjected to severe ground movement and did not fail. The filtration plant suffered major structural damage with an estimated vertical settlement of 2 feet and lateral movement

of 1.6 feet. There was liquefaction of fill soils during the violent shaking. Several fissures occurred across the area.

The material in these lines and construction is the same as that contemplated for the SOHIO line. The 30-inch line was .375-inch wall, API-5LX-52. These lines were excavated and inspected for excess stress resulting from the earthquake. The 30-inch lines were hydrostatically tested to 1170 to 1274 psi for a period of 24 hours without leaks or failure.

Strain gauge examination determined there was excessive stress on some portions based on the formula:

$$\text{Stress} = \frac{E(Gx10^{-6})}{B}$$

E = Young's modules

G = Average of transverse and longitudinal gauge readings in micro inches x 10^{-6}

B = Biaxial coefficient = 1.3

A distance of 3,000 feet of the 30 inch lines was exposed and the lines cut at one end to permit the lines to seek a neutral position. The total stress relief was 28,600 psi tension and 8,080 psi compression in the one line and 13,700 psi tension in the other line.

Based on this data, design and construction considerations could be incorporated in the SOHIO pipeline to eliminate the possibility of failure during an earthquake of the magnitude of the Sylmar earthquake.

An analytical review of the Redlands Pump Station and the pipeline span over the San Pedro River near Redington, Arizona, was performed. Piping stress analysis was by computer program MEL-21P, an updated version of MEC-21. A detailed pump station piping and equipment stress analysis is being performed in conjunction with the design of pump foundation, piping, and piping supports. This analysis is being made using the TRIFLEX computer for

static (pressure, temperature, and weight) and the ANSYS computer model for dynamic stresses. The Holmes and Narver/Dames and Moore Report 5113.4R and 5113.6R are being utilized for the seismic design basis on the pump stations. In addition, detailed site soil investigations are being made at each pump station site to assure adequate foundation design information. The next result of this analysis will be to limit the equipment stresses to a level below the limit allowed by the equipment manufacturer. Allowable forces and movements on pump flanges have not been resolved within the industry. API Standard 610, Centrifugal Pumps for General Refinery Service states pumps with 4-inch nozzles or larger shall have the loadings substantiated by calculations or tests. To date, there has been minimal responses to this requirement. The question, however, is very important since a frequent source of pump alignment problems, bearing, and mechanical seal failures can be attributed to stresses placed on the pump by piping loads.

Section 419.6.4, Stress Values in ANSI B31.4-1974 Liquid Petroleum Transportation Piping Systems, covers the computation of longitudinal compressive stress due to the combined effects of temperature rise and fluid pressure on restrained and unrestrained lines. The buried pipe in this system is not sensitive to the temperature differences.

Provisions should be made to anchor lines entering and leaving the pump stations before and after the pig receivers and launchers. The amount of restraint provided by buried lines as they enter the pumping station depends on soil conditions. The above anchors would minimize external forces on the receiver and launcher manifolds. The piping at the San Pedro River crossing is adequate to carry crude oil at the operating temperatures contemplated.

9.0 Materials of construction

Materials of construction are adequately covered in the following code references:

ANSI B31.4 - 1974	Code for Pressure Piping Liquid Petroleum Systems
ANSI B16.5 - 1973	Steel Pipe Flanges, Flanged Valves and Fittings
API-6D	Steel Gate, Plug Ballance Check Valves for Pipeline Service
API-610	Centrifugal Pumps for General Refinery Service
API-650	Welded Steel Tanks for Oil Storage

10.0 Cathodic protection

The existing gaslines planned for conversion to crude oil are presently under cathodic protection. This protection is part of an overall cathodic protection system of several adjacent pipelines operated and maintained by the gas companies. These lines should be maintained in this present system with the responsibility for operation and maintenance retained with the gas companies. New lines installed by SOHIO Transportation Company can also parallel existing cathodically protected lines and would need to be integrated into these systems with responsibilities for operation and maintenance defined preferably the sole responsibility of one of the parties.

11.0 Emergency power

Reference is made to the use of backup generators or batteries to insure operation of critical control equipment. Uninterruptible power supplies are being provided where needed for backup power for computer systems. Other locations will be provided with battery backup system for instrumentation,

control and communications equipment. Battery or generator powered emergency lighting will be installed where needed.

Spare transformers in the required sizes would be available in case of an emergency from local power companies and would be stored in adjacent locations to minimize delays in power restoration.

12.0 Fire protection

12.1 Tank fire protection systems -- general

The planned use of pontoon floating roof tanks for crude oil storage is the most desirable type storage tank in minimizing tank fires. Oil tank fires can be attributed to two basic causes; i.e., electrical storms and over-filling of the tanks. Electrical ignition of a floating roof tank is confined to the seal space between the roof seal and shell where an explosive vapor mixture may occur due to lack of contact of the seal with the shell or during rapid tank discharge when an explosive mixture may collect at the seal.

However, fire frequency on floating roof tanks is low considering the number of floating roof tanks in service. An American Petroleum Institute survey of floating roof tank fires from 1940 through 1950 showed 26 reportable fires, 23 of which were ignited at the seal by lightning.

12.2 Tank fire protection system

With the low frequency of floating roof tank fires, experience in fighting such fires is rather minimal and there is not a consensus of opinion in the best method of extinguishing them.

Serious consideration should be given to a fixed fluroprotein foam system for fighting tank seal fires. The system would consist of foam header placed around the exterior of the tank on the wind girder with periodic foam risers, foam makers and over-the-rim foam dispensers equally spaced at about 80 foot intervals, around the tank circumference.

Subsurface application of foam is not considered practical because of the inability of concentrating the foam layer in the seal space area. The use of synthetic Aqueous Film Forming Foam is not recommended because of its "susceptibility to break down, loss of burnback resistance and failure to seal against a tank shell as a result of free burning prior to agent discharge" (NFPA bulletin No. 11B).

Fixed automated halogenated fire extinguishing systems have been installed on floating roof tanks in Europe and Asia, but experience in the United States is limited.

Crude oil floating roof tanks in the range of 195 feet to 233 feet in diameter and 56 feet high provided with urethane or oil filled tube seals have experienced lightning generated tube seal fires that have been extinguished in about one hour utilizing fluroprotein foam.

To adequately distribute foam to the tank seal, foam dams of 18 inches in height and spaced 24 inches from the shell would be installed around the circumference of the floating roof. This will satisfy requirements of NFPA-11.

12.3 Floating roof ground

The use of metal straps or shunts between the roof and the shell spaced at 10 foot intervals are recommended to drain off bound electrical charges on the roof. Electric storms involve heavily charged clouds and create an

electric field on the earth below the cloud. The field induces an opposite charge on the earth's surface including storage tanks and their floating roofs. When lightning strikes the field, in the general area below the cloud, it collapses and a heavy ground current flows toward the point of lightning impact.

With an unbonded floating roof, the bound charge is relatively insulated and retained for an instant with a resulting spark over to the shell and ignition of any vapors present. Metal straps or shunts between the roof and the shell will permit the charge to immediately bleed off to "ground."

12.4 <u>Pump bays and piping manifolds</u>

Installation of 1-1/2-inch water hose stations with the capability of providing water fog to protect fire fighters in closing valves in pipe lines under exposure are recommended. Adequate hose stations should be installed to provide fog coverage for the entire pump bay and manifold.

Preferably pump bays and pipe manifolds would be provided with foam containers and foam monitors strategically located so as to permit foam blanketing of the pump and manifold.

12.5 <u>Dike fires</u>

Normal practice has been to equally space tanks in the center of a diked area and provide low curbs around the tanks to minimize the spread of oil to adjacent tanks. A better design to minimize tank exposure to fires is to elevate the tanks, maximize the distance between them, locate them nearer the dike or fire wall, and grading the area within the dike to drain any spill a maximum distance from the tanks.

Section 1F Construction and restoration

1.0 Estimated construction materials

Apparently Table 1F-1 does not include the copper, steel, etc., required by the utilities to construct the overhead lines to the pump station sites. This should be included. The use of alternate materials, plastic conduit versus. steel and aluminum cable vs. copper should also be considered.

2.0 Disposal of hydrostatic test water

As stated in Chapter 1, Section 1.2.3.2, hydrostatic test waters after utilization will be analyzed, treated if necessary, and disposed of in accordance with Federal, state and local regulations.

3.0 Protective coating

The coating systems being considered for the new portions of the pipeline are: (1) 14 mils of thermosetting epoxy resin, (2) 10 mils of butyl primer with 40 mils of polyethylene outerwrap and (3) approximately 100 mils of coal tar enamel, spirally wrapped with perforated glass reinforced asbestos felt.

Where pipeline crosses highways, railroads, canals, rivers, lakes, drainage ditches, creeks, sloughs, etc., additional protection should be provided by additional coal tar thickness, heavier asbestos felt, polyethylene and glass cloth or a combination of these.

4.0 Tank construction

Careful inspections should be performed on the welding in the floating roof pontoons to assure each pontoon is entirely vapor tight, including the

pontoon access manway. Explosions have been known to occur in floating roof pontoons where an explosive mixture has collected.

Section 1G Operation and maintenance

1.0 Operation surveillance and control

Long Beach Terminal

A 24-hour operating staff of two is planned for the Long Beach Terminal. Personnel would monitor and control the activities at the Dominguez Hills Terminal through the SCADA System. Additional operations personnel will be provided for the Port Facilities as required by tanker traffic.

At both the Port and the Dominguez Hills Terminal, each tank will be provided with remote gaging devices to measure tank levels along with secondary independent high level alarm instruments and high-high level automatic shutdown devices to aid operators and to ensure against overflow of any of the tanks.

Oil water separators and coalescer pressure filter effluents will be inspected and released as per Environmental Protection Agency state and local regulations. The oily water treatment system will be designed to treat the maximum expected rainwater load.

The installation of custody transfer stations at points of delivery to local refineries (instead of at the terminal) would allow continuous operation and more efficient use of the local pipeline distribution system that is planned for delivery of crude oil. Such installation would increase the capacity of the system, reduce operator work load and improve the safety of operation by eliminating the necessary line-ups of a batch system.

The motor-operated valves planned by SOHIO in the terminals should improve the safety of operation of the terminals. A control board of the graphic or semigraphic type (possibly already planned by SOHIO) would reduce the possibilities of line-up errors.

2.0 Pump stations

The piping diagram of a typical pump station furnished by SOHIO did not indicate the intended instrumentation, no doubt due to the current early stage of engineering. As a minimum, however, we would anticipate the following instrumentation:

1. Remote operation (and obviously local) of motor operated valves from Long Beach or Midland terminals with position indicators.

2. Local and remote pressure recorder control for the station discharge pressure.

3. Local and remote pressure recording of suction pressure (with alarms and automatic shutdown of pumps on low pressure).

4. Local and remote differential pressure indication for each metering station (with alarm on high differential pressure).

5. Local and remote rate indication (with totalizing) of meters (SOHIO already plans this).

6. Remote run lights and remote start and stop features for pumps.

7. Automatic shutdown control for individual pumps with local and remote alarm and "first out" indication for the following:

- Ground fault
- Vibration
- Seal leakage
- Fire
- Low suction pressure
- Low flow
- High bearing or lube oil temperature
- Low lube oil pressure

8. Level control of the waste water (and oil) sump with remote alarm of high level.

9. Remote run light for the sump pump.

10. Electric tracing of the sump, level control device and sump piping should be considered to ensure against residual water from the "last rainstorm" freezing and preventing proper disposal of oil leakage during cold weather.

11. Each pump station will contain heat sensors with indications or alarms being sent to the pipeline dispatcher, however, automatic fire extinguishment facilities are not planned for the pump stations. Dry chemical fire-fighting equipment will be located at each station.

12. Provision for portable meter proving equipment. Possibly piping could be arranged to prove one meter with another on-stream meter.

The sump facilities should be sized to accommodate the rain runoff from pads and bases diverted to the sump because of oil spill potential.

Midland Terminal

Comments are similar to those for the Dominguez Hills Terminal in regard to level devices, motor-operated valves and oil-water separation.

Other comments

Automatic temperature compensation for the pipeline meters is possibly already planned by SOHIO. This should improve the ability to detect leaks by meter difference.

We believe that SOHIO computerized meter reconciliation will be able to detect leaks amounting to less than 0.50 percent since only a comparison of metered area is accomplished -- not absolute metered volume by each meter.

3.0 Operations and maintenance

SOHIO's proposal indicates, in a general way, that operating and maintenance personnel would be adequately trained. Actually, there are many tasks to be performed before actual startup of a newly constructed oil processing or transportation facility. While obviously SOHIO is knowledgeable of the various facets of a startup, a generalized outline of prestartup activities is presented here for amplification.

3.1 Outline of prestartup activities

3.1.1 Organization and staffing

Devise organization structure

Define policies

Prepare position descriptions and job classifications

Prepare work guides

Prepare work breakdowns for each job

3.1.2 Preparation of operating instructions

Startup manuals

Operational guides

Standing instructions

Daily instructions

Emergency instructions

Disaster organization and procedures

Industrial defense procedures

Safe practices and standards

Fire permit procedures

Equipment summaries and information

3.1.3 Design reporting systems

Computer outputs

Logs and board sheets

Laboratory logs

Bleed and vent checklists

Leak tag lists

Operating reports

Forecasts

Data summaries

Inventory projections

Effluent water quality reporting

3.1.4 Train and qualify personnel

Indoctrination

Basic training

Classroom training

Model training

Field training

Operations simulator

Emergency simulations

Live fire training

First aid training

Testing and qualifications

Craft training

Standards of performance

Rules of behavior

3.1.5 Conduct plant readiness inspections and checkout

Review contractor/owner interface and assign responsibilities

Final design review for oversights and other additions to facilitate startup

Internal inspection as required

Trace lines and check equipment

Witness contractors' tests as required

Coordinate punch lists

Check bleeds and vents

Prepare engineering data book

Special inspections required by insurance or governmental agencies

Witness rotating equipment cold alignment

Governors and safety devices on rotating equipment

Test and adjust all safety and relief valves and seal as necessary

Check for removal of rust preventatives

Make initial measurements as basis for subsequent corrosion inspection

4.0 Pump and pipeline maintenance

Consideration should be given to preventative pump maintenance through vibrational analysis, preferably continuous. Changes in vibration pattern signal eminent bearing or seal problems and repair or replacement can be effected prior to failure.

Further definition is needed on the method of stopping and repairing pipeline leaks. Isolation of the repair sections and handling of any crude oil removed needs to be covered. A scenario that involves the use of water appears impractical.

A definite procedure for safe isolation of equipment for maintenance needs to be established covering isolation, personnel safety, fire protection, etc.

Section 1H.2 Design, construction and operating features for preventing and minimizing oil spills

1.0 General

Release of crude oil and exposure of the environment from a failure or malfunctioning of the system can occur in several ways.

With a general knowledge of SOHIO's designs of terminals, pumps stations and the pipeline, the following Fault Tree Diagrams have been constructed:

Figure 1H-1 Crude Oil Spill Potential

Figure 1H-2 Terminal Effluent System Failure

Figure 1H-3 Pump Station Effluent System Failure

Figure 1H-4 Pump Spill

Figure 1H-5 Tank Spill

Figure 1H-6 Pipeline Rupture

Figure 1H-7 Pipeline Leak

Logic symbols used in the diagrams are those used by the Environmental Protection Agency.

An event, usually a malfunction that results from a combination of other events.

A basic event or lowest identifiable condition or fault.

EITHER-OR, a situation whereby an output will exist if any or all output events are presented.

AND, the coexistence of all input events are required to produce the output.

Transfer symbol; connects to a more detailed diagram.

The probability P(A) that a specific hazard even will occur as the result of malfunctions or faults occurring is calculated as follows:

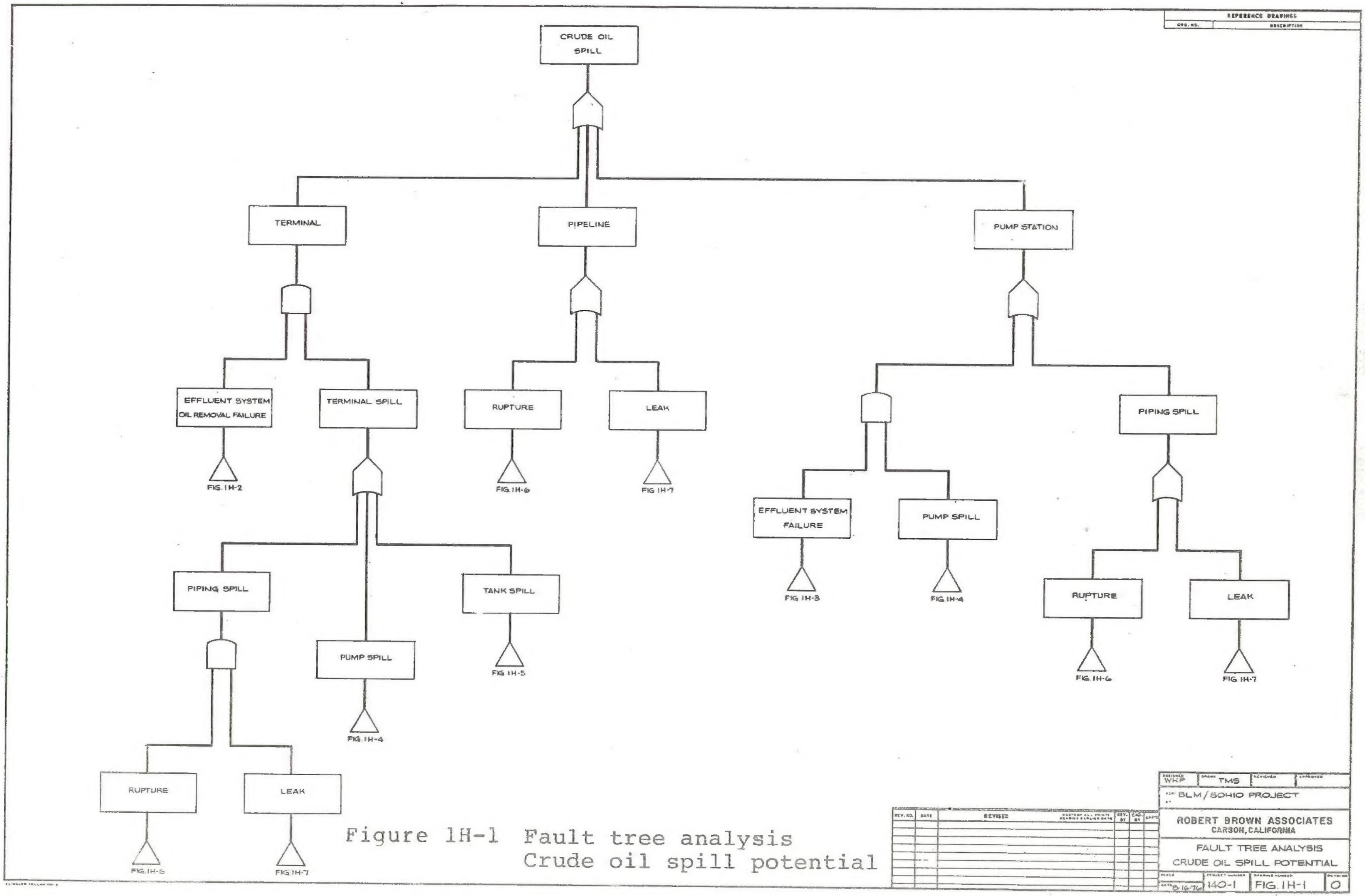


Figure 1H-1 Fault tree analysis
Crude oil spill potential

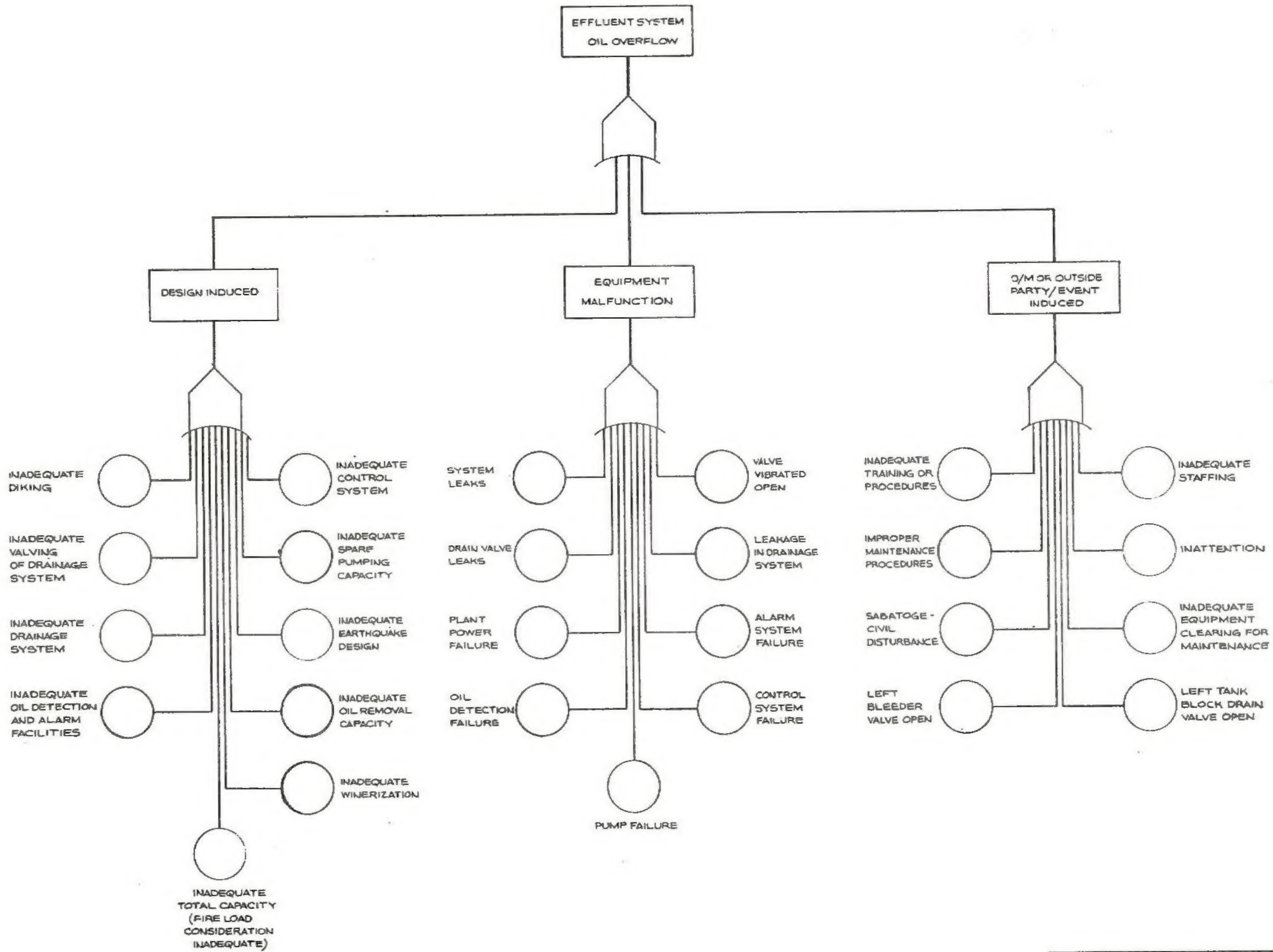


Figure 1H-2 Fault tree analysis
Terminal effluent system failure

WHP TMS
BLM/SOHIO PROJECT
ROBERT BROWN ASSOCIATES
CARSON, CALIFORNIA
FAULT TREE ANALYSIS
TERMINAL EFFLUENT
SYSTEM FAILURE
8-16-76 140-1 FIG. 1H-2 0

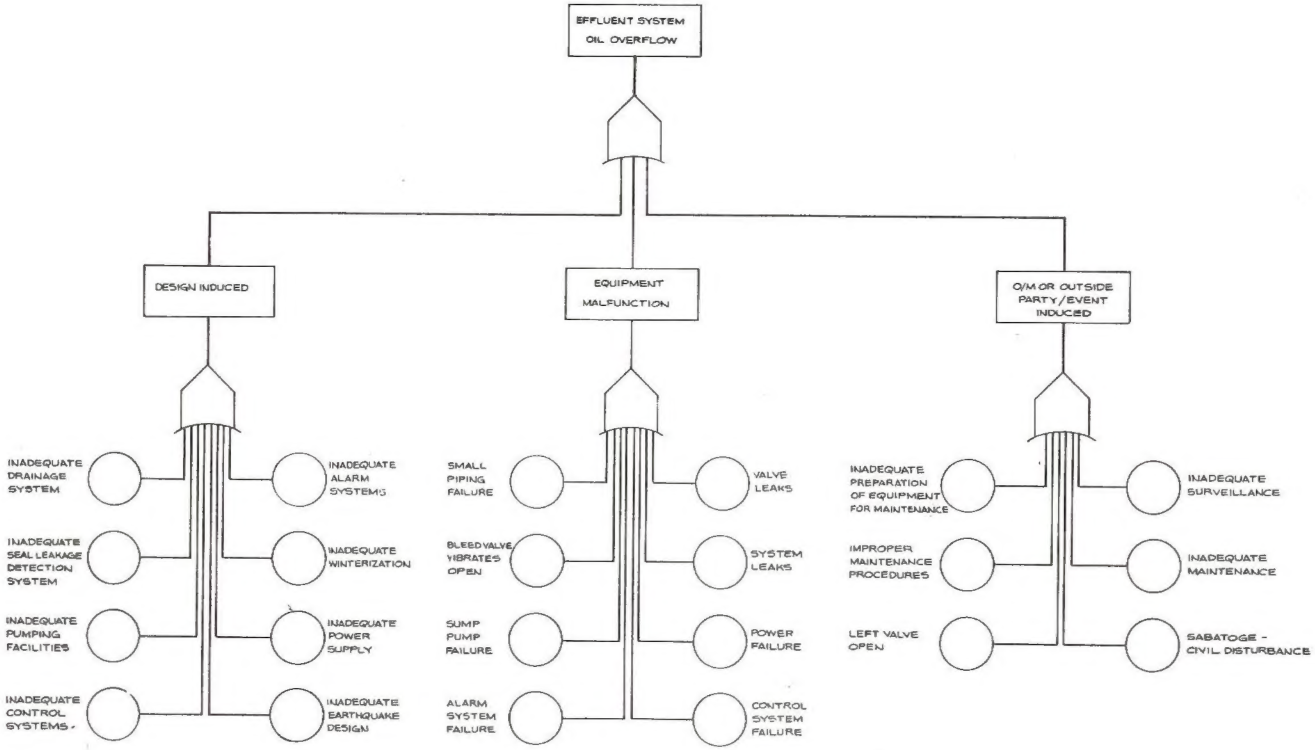


Figure 1H-3 Fault tree analysis
Pump station effluent system failure

REFERENCE DRAWINGS

DESIGNED	DRAWN	REVIEWED	APPROVED
WHP	TMS		

FOR BLM/SOHIO PROJECT

ROBERT BROWN ASSOCIATES
CARSON, CALIFORNIA

FAULT TREE ANALYSIS
PUMP STATION EFFLUENT
SYSTEM FAILURE

DATE	PROJECT NUMBER	DRAWING NUMBER	REVISION
8-16-76	140-1	FIG. 1H-3	0

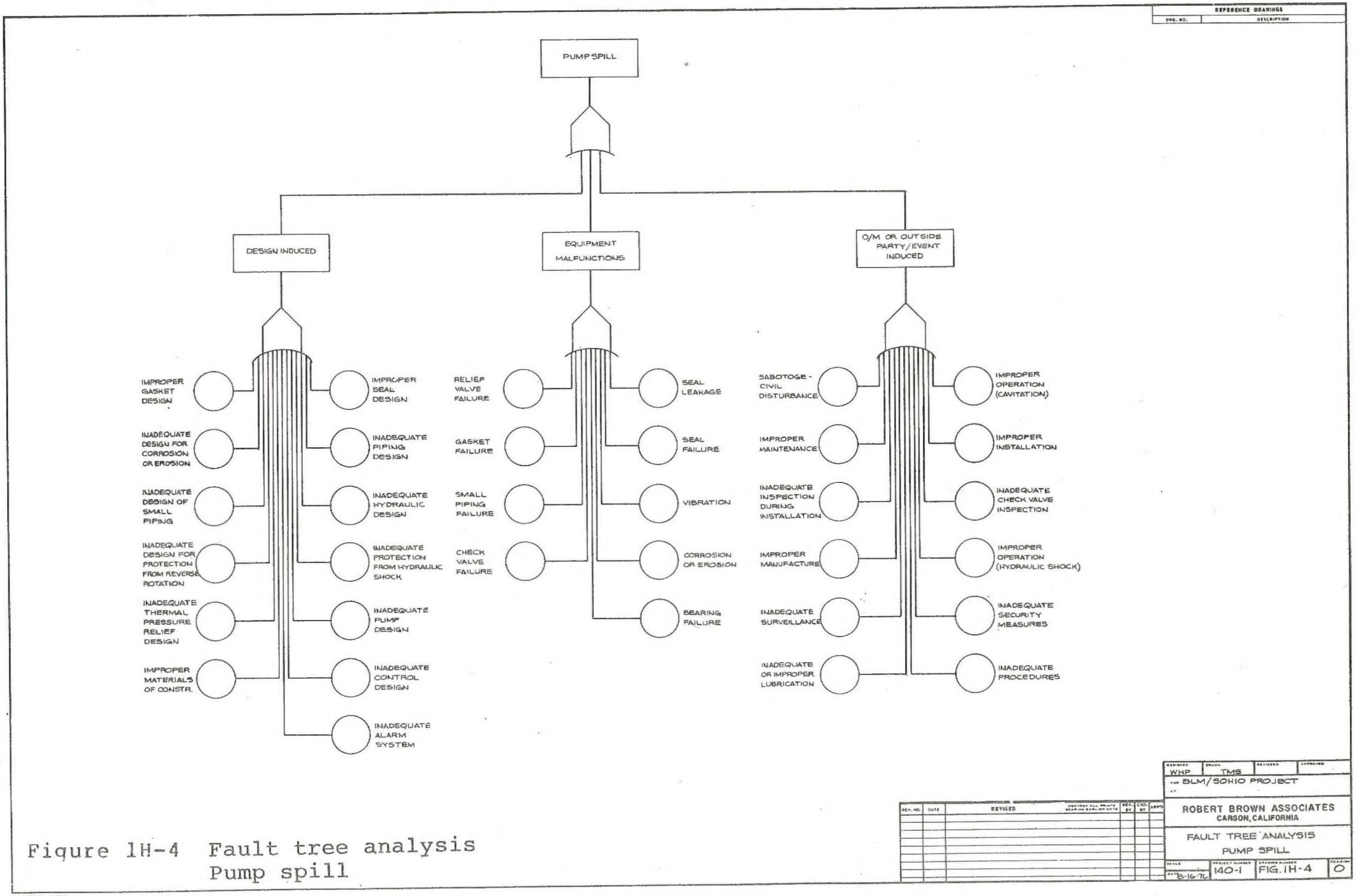


Figure 1H-4 Fault tree analysis
Pump spill

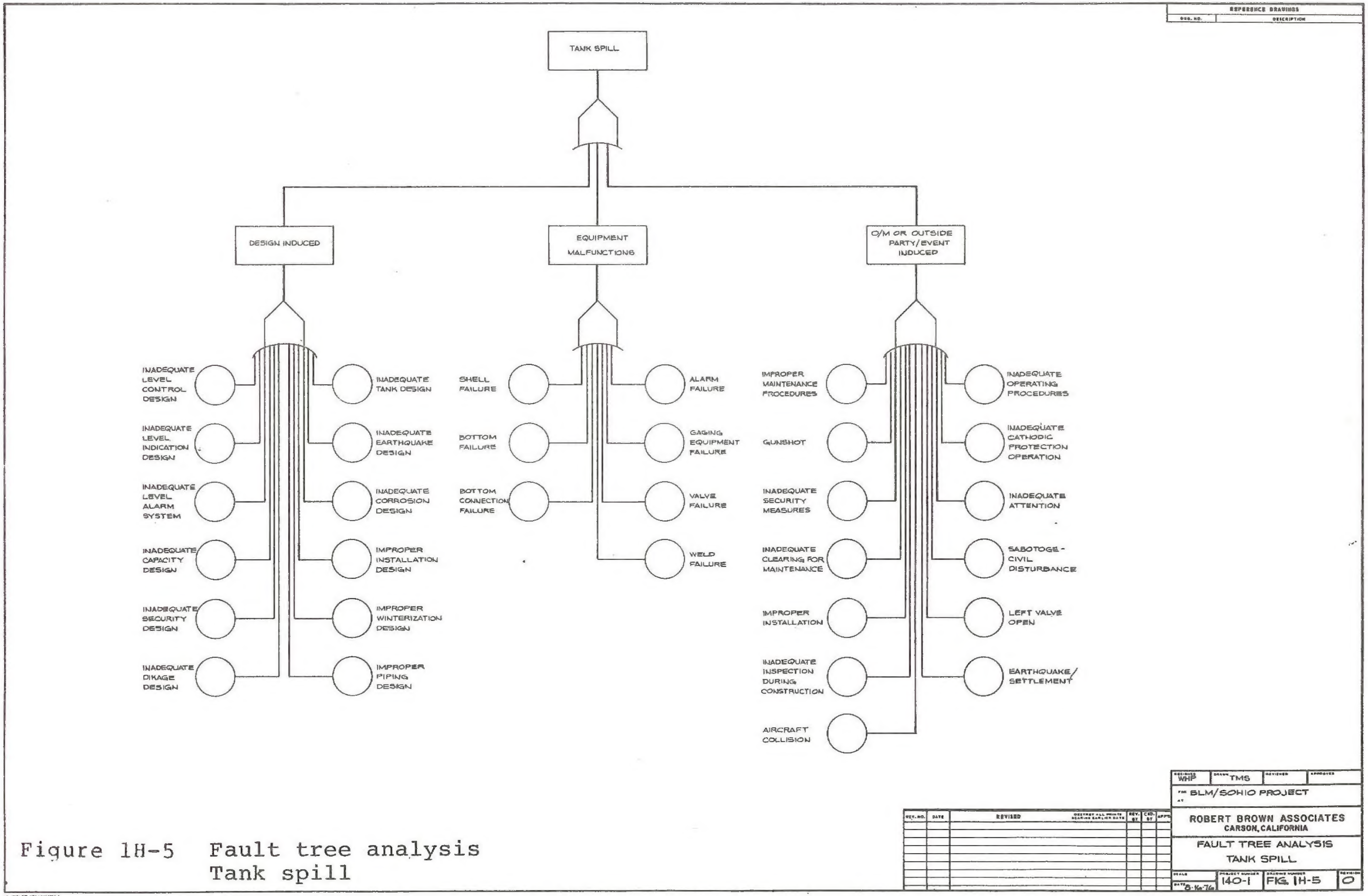


Figure 1H-5 Fault tree analysis
Tank spill

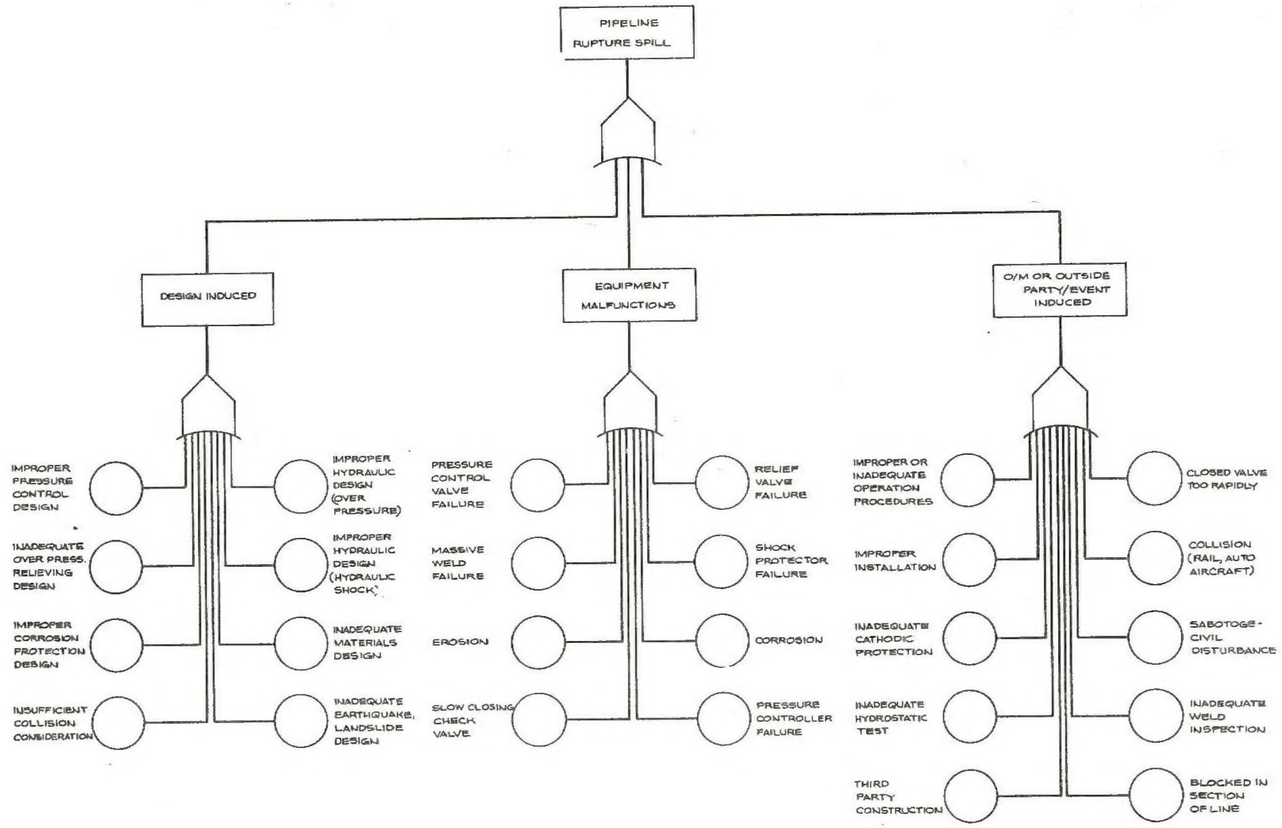


Figure 1H-6 Fault tree analysis, Pipeline rupture

WHP TMS
BLM/SOHIO PROJECT
ROBERT BROWN ASSOCIATES
CARSON, CALIFORNIA
FAULT TREE ANALYSIS
PIPELINE RUPTURE
8-16-76 140-1 FIG. 1H-6 0

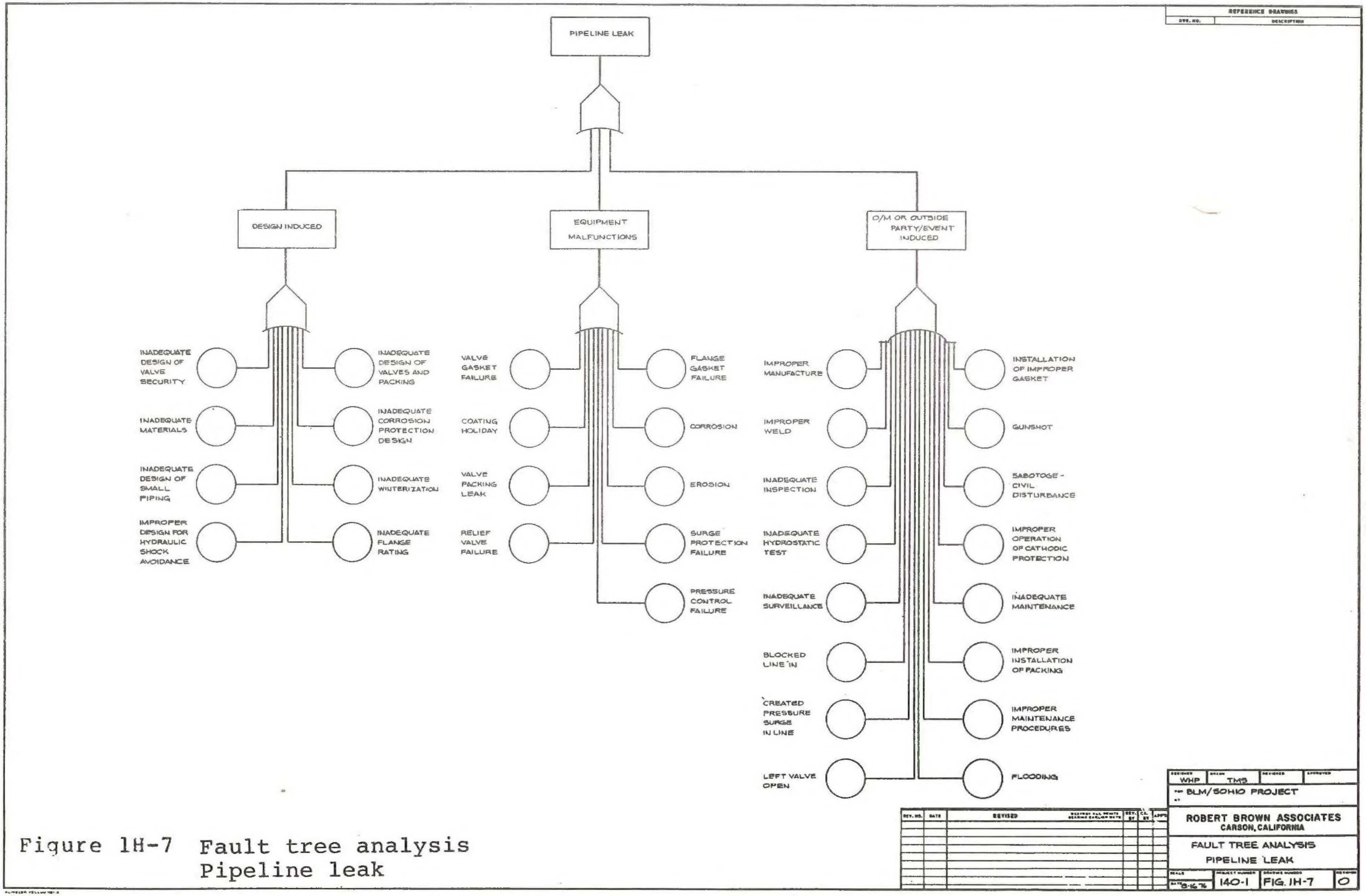


Figure 1H-7 Fault tree analysis
Pipeline leak

In the EITHER-OR situations, the probability that a specifiic hazard will occur as the result of one or more malfunctions or fault events may be expressed as:

$$P(A) = \prod_{i=1}^{n} Q(B_i)$$

where $Q(B_i)$ = probability that a specific hazard malfunction will not occur.

n = number of fault conditions that contribute to a specific hazard.

In the AND situation the probability that a specific hazard will occur may be presented as follows:

$$P(A) = \prod_{i=1}^{n} P(B_i)$$

where $P(B_i)$ = the probability that the causative malfunction will occur.

1.1 Pipeline leak or rupture

1.1.1 External damage from excavation or construction equipment. This is the most probable cause of a release of crude oil and the resultant hazard.

1.1.2 Minor "weepage" or leaks may occur due to pinholes in welds and corrosion.

1.1.3 Over pressuring due to malfunctioning of the equipment, such as exceeding the capacity of the surge system.

1.1.4 Vandalism such as bullet holes in the exposed portions of the line.

1.2 Failure of equipment

1.2.1 Pump bearing or mechanical seal failure.

1.2.2 Packing or gasket leaks in valves and piping.

1.2.3 Corrosion in a tank bottom.

1.2.4 Rupture of the tank, shell or tank nozzle connection due to seismic forces over and above that for which the tank was designed.

1.2.5 Failure of the terminal or pump station water treating facilities.

1.3 Operating errors

Operating errors can happen and do if proper standing instructions are not written, operators are not properly trained and proper procedural methods are not enforced. A few of the more common errors follow:

1.3.1 Leaving vent or bleed valve open on equipment being activated.

1.3.2 Leaving tank dike drain valve open (except when draining water from tank dike area).

1.3.3 Allowing roof drain valve to be open except when draining water from the roof.

1.3.4 Destroying pump seals by allowing cavitation of the pump.

1.3.5 Leaving plugs out of (or not blind flanging) small valved piping bleeds and vents. Vibration opens valves occasionally.

1.3.6 Overfilling a tank by reason of inattention or not routinely checking the automatic gauging device with a hand gauge.

1.3.7 Not properly isolating equipment to be maintained from active equipment before opening for maintenance.

1.3.8 Not checking for integrity of equipment before reactivating after maintenance or new construction.

1.3.9 Not properly clearing equipment of hydrocarbons before turning over to maintenance crews for opening.

1.3.10 Inattention of oil level in oil-water separator.

1.3.11 Sudden closure of valves.

1.3.12 Reliance upon check valves for shutoff.

1.3.13 Blocking in lengthy sections of pipeline between valves without relief provision.

1.3.14 Inattention to excessive vibration of rotating equipment before failure.

1.3.15 Improper lubrication of rotating equipment causing bearing failure.

1.3.16 Improper line-up.

2.0 Pipeline leak or rupture

The most probable cause of a leak in the pipeline is third party equipment rupturing the line during the course of a construction project. Every precaution should be taken to prevent such an occurrence. This would include surface identification of the route, continuing surveillance with permit authorities of construction planned in the area, contacting permitted construction companies and reviewing their construction schedule, meeting with construction personnel in the field and identifying location of the line and its depth in the working area. Continuing visual inspection of the route of any construction activity.

2.1 Minor line leaks

Minor leaks can be expected around the gaskets and packing in the pump and tank manifolds. Design features incorporated to collect and handle such spills should protect against any adverse effect on the environment. Leaks in the pipeline due to faulty workmanship and corrosion can all but be eliminated through the proper selection of materials, through inspection of the quality of the workmanship and cathodic protection of the system to prevent corrosion.

There are, however, sections of the proposed gaslines to be converted into crude oil that can be expected to experience minor leaks, namely lines 1103 and 1110 of the El Paso Natural Gas Line Company System. Portions of the lines were installed some 25 years ago and have experienced minor weld and corrosion leaks. Some two or three leaks a year can be expected in these lines in a volume of a few gallons to several barrels an hour which will continue until detected by visual observation.

In addition to the destruction of vegetation of the area, there could be an adverse effect on range cattle. Domestic animals have not been known to eat such vegetation but range cattle will and do.

2.2 Overpressuring of the system

A sudden closing of a control valve such as the dropping of a plug through a shaft failure, a malfunction of a check valve where it suddenly closes or closing of gate valve too quickly can create a surge of pressure in the line to where it is overpressured and leaks. The leak would in all probability occur in gaskets or packing. However, the pressure could be sufficient to rupture a valve or the pipe with the resultant oil spill.

Section 1E.3.4, Pressure Surges and Static Heads, states relief valves and surge tank would be located as needed to protect a pipe section as necessary. Instantaneous surges which cannot normally be contained by the pipeline will be handled by relief valves properly sized for this purpose.

2.3 Vandalism

It is not uncommon for an elevated pipeline running through a remote region to be penetrated by a rifle bullet. Should this occur, there would be some 60 bbl/hr of crude oil flowing until the line is shut down. There is the remote possibility this would happen in an overhead stream crossing with the resultant contamination.

2.4 Washouts

Should a flash flood occur, the scouring action could expose the pipe at which point there could be a pipeline failure. A thorough evaluation of each river, creek or wash crossing is necessary in order to establish the proper depth to protect the line from exposure.

Experience to date on the existing gaslines has been good. There has not been any damage or failure due to a washout. However, should a flood expose the line, current induced oscillation and bumping against a rock outcrop could cause failure.

Water flow across a pipe can cause the formation of eddies or vortexes downstream in an irregular pattern. Shedding of these eddies causes hydraulic pressure differentials which in turn can cause the line to vibrate and fail. Reference -- "Vortex Shedding Can Cause Pipelines to Break," by M.J. Mes Pipeline and Gas Journal, August, 1976.

3.0 Failure of equipment

3.1 Pump bearing or mechanical seal failure

Failure of pump bearings and mechanical seals are relatively common and can be expected. While the system is designed to shut down in case of such an occurrence, there could be a substantial amount of oil escape. Provisions to rapidly drain this from the immediate area should be provided by grading the area to slope away from the pumps into a remote sump.

Also in case of such a failure, exposure of the substation, switch gear and control cubicle should be minimized preferably by placing them some distance from the pumps and manifold.

3.2 Packing or gasket leaks

Reference is made in the EIA to drop collections sytems at the pump station scraper traps and Midland Terminal piping. It can be expected that all areas around valves, flanges and rotating equipment will have leakage if not during operations certainly during maintenance and repairs. These areas in

terminals and pumping stations need to be paved and curbed with an oil collecting drainage system.

3.3 Tank bottom corrosion

With the added thickness, internal coating and soil preparation planned for the tank bottom there is little likelihood of a corrosion leak in a tank bottom. It would be advisable, however, to have a small telltale pipes installed under the bottom and running to the outside circumference of the tank in order that any leakage, should it occur, could be readily detected.

3.4 Rupture of tanks or tank connections

While the response spectra selected for the Dominguez Hills Terminal tank design should provide adequate safety for resistance of contingency level earthquakes, there is the remote possibility that the design level will be exceeded. Also, during an earthquake, nozzle connections at tanks could rupture and release crude oil.

Earthen retention dikes at the Dominguez Hills Terminal will be provided for retaining the crude oil. The design will meet NFPA-30 Los Angeles City Fire Code, 1972 Edition, Division 31, and OSHA, 1974 Edition, Section 1910-106 standards, although, this site is outside the city limits of both Los Angeles and Long Beach.

3.5 Waste water collection

Section 1E.2.7 of the report calls for collection of terminal storm water runoff and treating before discharge if required. It may be necessary to treat storm water before discharge in order to meet water quality standards as stipulated by Federal, state and local water quality boards.

The water treating system will need an alarm, such as a reflectometer alarm or similar type instrument, to alert the operators of excess oil in the waste water.

Under normal conditions, approximately 70 percent of all rainwater runoff within the terminal area will be uncontaminated.

The terminal containment basis would feature oil and water monitors to indicate the necessity for treatment and/or the degree of treatment.

Section 1H.4 Contingency plans

1.0 Fire protection

Fire protection and fire fighting techniques for the proposed project will be an integral part of the emergency operating procedures.

Staffing at the terminals will not be adequate for fighting a major fire and it will be necessary to call for outside assistance. General guidelines, knowledge of applications of principles of fire fighting and a working familiarity with the use of the fire fighting equipment on hand is needed. Experience with large oil fires have clearly shown that, as a rule, exceptionally high losses have resulted from human error following inadequate or no prefire planning for the emergency, either by management or the local fire department or both.

As a part of the contingency plan, fire drills should be conducted in the field on selected types of emergencies and in as realistic a manner as practical.

1.1 Fire drills

The purpose for such work is to train firemen and operating supervisors on the fundamentals so as to:

1.1.1 Size up different types of larger fires that can be encountered.

1.1.2 Select the best strategy and tactics to use depending upon the situation.

1.1.3 Know the use and limitation of water, foam and dry chemical.

1.1.4 Find and correct deficiencies in fire-fighting facilities, equipment, and organizations.

1.1.5 Check emergency communication problems and improvement in coordination between operating people and firefighter's supervision during the stress of emergencies.

1.2 Fire fighting plan

At the terminal, the handling of a large or serious spill, fire, or potential fire emergency involves two organizations working together on a single problem.

1.2.1 The terminal people on shift whose prime emergency responsibility is to promptly shut down operating equipment or perform other operating duties to prevent a fire or to reduce the size, severity and duration of a fire, once started.

1.2.2 The Local Fire Department units that provide manpower and pumping equipment to control and extinguish the fire with related duties.

1.2.3 Each must know the other's basic plans and efforts so as to coordinate their work towards a common end. This means the terminal and Fire Department people working together in the development of and conducting the prefire plan training consisting of:

1.2.3.1 Selecting a few practical serious emergency problems that can happen.

1.2.3.2 Assigning one man who would briefly outline a problem and possible solution and: check it with the operating supervisors and correct as needed; check it with the local fire-fighting chief and correct as needed.

1.2.3.3 Meeting with operating supervisor and chief in the field and plan for a practical drill on the selected problem. Plans should be made for a slow drill initially to acquaint everyone with the fire-fighting equipment, its limitations, and capabilities and learn the hydrant locations, the layout of the operating equipment in the simulated fire area, the access and escape ways (assuming darkness and heavy smoke), etc. Discuss problems of logistics, timing, equipment shutdown to stop flow of fuel that is feeding the fire, possible fire damage to remote control equipment, effect of pressure drop through long hose lays in tank block areas, effect of wind on long reach of water cooling streams, damage of foam by water streams, using water wisely to avoid flooding sewers and spreading fire, etc.

1.2.3.4 Redrafting the drill plan and define exactly the time (day or night), the location, type, size, and kind of fire, wind direction, etc., and outline the jointly agreed to best firefighting procedure.

1.2.3.5 Conducting the initial try out or slow drill, using applicable firefighting equipment, strategy and tactics in as realistic a way as possible. Determine errors in the original plan and correct.

1.3 Fire training program

This training would teach all men involved that:

1.3.1 Supervisors (both terminal and Fire Department) must make prompt and accurate sizeups of emergencies and fires at the start because indecision and unskilled leadership can lead to disastrous loss of property and loss of life. Also, continued sizeup during the course of the fire is essential when there are changes in the problem.

1.3.2 For supervisors and men to be competent and reliable in the stress of severe emergency, it is vital that they personally and actively participate in prefire plan training covering all phases of possible serious emergency situations that they may encounter.

1.3.3 That a continuing program with refresher training on old problems and new training on new problems needs to be part of the plan.

1.4 Pump stations

Reference is made that pump stations will follow the outline of Section 1H.1.1. This section is a historical perspective of causes and frequencies of oil spills from pipelines and does not speak to a pump station contingency plan. Section 1H.4.1.3.2 Terminal Pump Valves and Piping states if a fire hazard existed, the oil surface would be blanketed with foam using readily available fire extinguishers.

It can be expected that a similar exposure could occur at the remote operated pipeline pump stations. Should this happen, personnel would not be readily available to apply foam as in the terminal. Provisions for prompt fire fighting should be provided. There is the distinct possibility of a fire at these remote pump stations with the resultant contamination potential.

As a minimum, an automated dry chemical firefighting system should be provided. This would minimize the leak potential from flanges and valve stems, sources that frequently feed a fire making it difficult to contain.

REFERENCES

Appendix A1.0

Evaluation of Existing Pipeline -- References

1. El Paso Natural Gas Company Coating, Wrapping and Cathodic Protection Study by Engineering Department, Corrosion Division, Design Engineering Group -- April, 1976.

2. El Paso Natural Gas Company Construction Contract Spread V 30-inch Line 1600 M.P. 486.2 to M.P. 522.83 -- 1969.

3. El Paso Natural Gas Company -- Department Codes and Standards Hydrostatic Test Summary, 9-26-74.

4. El Paso Natural Gas Company Operating Department Cathodic Protection Station In-Service Reports, 1972-1975.

5. El Paso Natural Gas Company Operating Department Lines 1103, 1110 and 1600 Leak Reports, 1972-1975.

6. Construction Specifications for Line 2001: G.W.O-57020-U, 1950; G.W.O-86017-T.P., 1953; G.W.O-88807-T.P., 1955.

7. El Paso Natural Gas Company Route Map.

8. El Paso Natural Gas Company Specification for Electric Welded Line Pipe to A.O. Smith Corp. S.O. No.5576, Dated 11-13-68, and A.O. Smith Laboratory Material Tests on S.O. No.5576, Dated 2-4069; Republic Steel

Corp. Laboratory Material Tests on P.O.80917, 81329, 80433 and 80397; Kaiser Steel Certified Report of Physical Properties and Chemical Analysis of Pipe Co., No.86504, 81373, 86504, 86389, 87101, Dated 12-11-68; United States Steel Corporation Standard Certified Test Report on C.O. No.81694, 85285, 85284, Dated 12-30-68 and 12-31-68; Moody Engineering Co. Inspection Report on U.S.S. Co. No.85285, Dated 4-18-69.

9. El Paso Natural Gas Company Welding Inspections -- Line 1600 W.O.-C-1022 and C-1016 by McVean and Barlow, Inc.; Monroe X-Ray Company and Conam Inspection.

10. Southern California Gas Company Annual Report -- Operating and Maintenance Studies -- Line 2001, Years 1972-1975.

11. Southern California Gas Company -- Cathodic Potential Surveys of Line 2001, Dated 1956, 1965, 1976.

12. Southern California Gas Company -- Cathodic Protection Test Station Potential Measurements, 1953-1975.

13. Southern California Gas Company Material Specifications for Line 2001, G.W.O-57020-U, Moody Engineering Company Report 8-31-50 and Consolidated Western Steel Corporation Laboratory Report Job No.48098, 7-31-50.

14. Southern California Gas Company Material Specifications for Line 2001 G.W.O-86006-U, Material Transfers #6762, 6763, 6768 and 6783.

15. Southern California Gas Company Material Specifications for Line 2001, G.W.O-88807-U, Material Transfers #3618, 3619, 3621.

Appendix A1.0

16. Southern California Gas Company Material Specifications for Line 2001, G.W.O-86017-T.P., Material Transfers #6818, 6819, 6875, 6876, 6906, 6907.

17. Southern California Gas Company Route Maps.

18. Southern California Gas Company Test Pressure Reports, 1957-1975.

19. Personnel Interviewed: El Paso Natural Gas Company

    Donald M. Schneider - Chief Project Engineer

    H.M. Savalle - Engineer

    Harry L. Moseley - Chief Standards Engineer

    A.E. McElroy - General Construction Superintendent

    T.B. LaRock - Chief Metallurgist

    Walter Chapman - Chief Corrosion Engineer

    Ralph Gibbons - Coating Engineer

    Southern California Gas Company

    George Haninger - Staff Supervisor, Engineering Dept.

    Ron Benz - Engineer

    M.A. Forster - Associate Engineer

    Robert E. Hoyer - General Superintendent - South Inland Transmission Division

    Harold Carson - Pipeline Superintendent - South Inland Transmission Division

Design

1. American National Standard

   ANSI B 31.4 - 1974 - Liquid Petroleum Transportation Systems

   ANSI B 16.5 - 1973 - Steel Pipe Flanges, Flanged Valves and Fittings.

Appendix A1.0

2. American Petroleum Institute Specifications

API - 650 Welded Steel Tanks for Oil Storage, July, 1973

API - 5LX High-Test Line Pipe, March, 1975

API - 6D Pipeline Valves, March, 1974

API - 610 Centrifugal Pumps for General Refinery Service, 1971

API - 1104 - Welding Pipelines and Related Facilities, July, 1973

3. API - RP - 1110 Pressure Testing of Liquid Petroleum Lines, January, 1972

API - RP - 1102 Liquid Petroleum Pipelines Crossing Railroads and Highways, September, 1968

API - RP - 500C Classifications of Areas for Electrical Installations at Petroleum and Gas Pipeline Transportation Facilities, Sept., 1966 (Reaffirmed 1974)

4. Coefficient of Friction for Pipe Coating Materials by J.B. Ligon and G.R. Mayer, Pipeline Industry, February, 1975

5. Corrosion and its Control published by The Oil and Gas Journal, 1969

6. How to Find Stress and Sag in Piping by F. Caplan, Plant Engineering, May, 1969

7. National Electric Code, 1975 NEC.

8. National Technical Information Service U.S. Department of Commerce TID-7024, Nuclear Reactors and Earthquakes, August, 1963

Appendix A1.0

9. Oil Insurance Association General Recommendations for Spacing No. 631 - 1972

10. Temperature Expansion and Contraction Stresses in Buried Pipelines by Fritz Karge - Petroleum Engineer, October, 1952

Fire protection references

1. API RP 2003 Third Edition, October, 1974 "Recommended Practice for Protection Against Ignition Arising Out of Static, Lightning and Stray Currents"

2. API Publication 2021 First Edition, November, 1974 "Guides for Fighting Fires In and Around Petroleum Storage Tanks"

3. National Fire Protection Association Bulletins
   - No. 11 Foam Extinguishing Systems, 1974
   - No. 11B Synthetic Foam and Combined Agent Systems, 1974
   - No. 12 Halogenated Extinguishing Agent Systems Halon 1301 A and B and 1211, 1973
   - No. 30 Flammable and Combustible Liquids Code, 1973
   - No. 77 Static Electricity, 1972
   - No. 78 Lightning Protection Code, 1975

4. Oil Insurance Association Loss Control Bulletin, Dated March, 1974, titled "Jumbo Oil Storage Tanks"

5. Oil Insurance Association General Recommendation for Spacing No. 631 -- 1972

Appendix A1.0

6. U.S. Department of Commerce National Bureau of Standards Handbook 46, Code for Protection Against Lightning.

Minimizing oil spills

1. Petroleum Systems Reliability Analysis, Volume II, Environmental Protection Technology Series.

APPENDIX A1.1.1.1

Equipment and Operations of Tankers

(Including Inert Gas Systems)

APPENDIX A1.1.1.1

Equipment and Operations of Tankers

(Including Inert Gas Systems)

Equipment and operations of tankers

This appendix begins with a discussion of basic tanker features and operations that apply to the SOHIO tankers and to the specifics of movement of Prudhoe Bay crude oil to Long Beach. Next there is a discussion of other features that have safety or cost benefits but are not expected to be on tankers which would use the Pier J Terminal during the first years of operation. Throughout, the discussion stresses principles that are directly or indirectly related to environmental impacts.

The loss of a ship or of a crude oil cargo entails costs in the millions of dollars. Some tanker companies recognized this and initiated development of two features, inert gas systems and segregated ballast, which they felt justified the added cost. British Petroleum has been the company most active in development of inert gas systems.

Inert gas systems for tankers

The need for inert gas systems. Corrrosion of steel and combustion or explosion of petroleum gases are possible only in the presence of oxygen. Ordinary air contains about 21 percent of oxygen and provides a more than adequate supply to support both corrosion and explosion if other conditions are met.

If the oxygen level in the cargo compartments of a tanker is reduced to below 11 percent, there is insufficient oxygen for a flammable mixture. If reduced to below 5 percent, there is a marked reduction in corrosion.

The object of the inert flue gas system (Table A1.1.1.1-1) is to reduce the oxygen level in the cargo compartments by filling the vapor space of cargo compartments with inert gas. The gas used usually is flue gas from the ships' boiler stacks, washed clean and cooled. With large tankers there is an adequate supply of flue gas from the boilers to fulfill this function.

Table A1.1.1.1-1

Component Parts of the Inert Gas System

COMPONENT	Equipment and Function
Inert gas generator	Main boiler of a steamship, or separate turbine engine
Flue gas scrubbing tower	This equipment washes out corrosive agents and cools the gas prior to delivery to the tanks
Flue gas blower	A single-stage centrifugal blower which draws the gas from the boiler uptakes through the scrubbing tower and delivers it to the deck distribution system
Deck distribution system	System gives warning of failure of blower units, low gas pressure, low units supply, high inert gas temperature, low CO_2 or high O_2 content in the boiler uptakes; system is located in pumping control room with a satellite unit in the safety control panel on the bridge.

Source: SOHIO Transportation Company of California.

The gases from an operating boiler normally contain about 10 percent water vapor, but since most methods of measurement of gas composition do not take this into account, it is usual to quote flue gas compositions on a water-free basis. Using this basis, the composition of the gases should be carbon dioxide (CO_2) 12 percent to 14 percent; oxygen (O_2) 2 percent to 4 percent; sulfur dioxide (SO_2) 0.2 percent to 0.3 percent; nitrogen (N_2) remainder (about 80 percent). The more efficient the combustion, the higher will be the proportion of CO_2 in the flue gases and the lower the proportion of O_2. After passing through the cooling and cleaning process, the gas

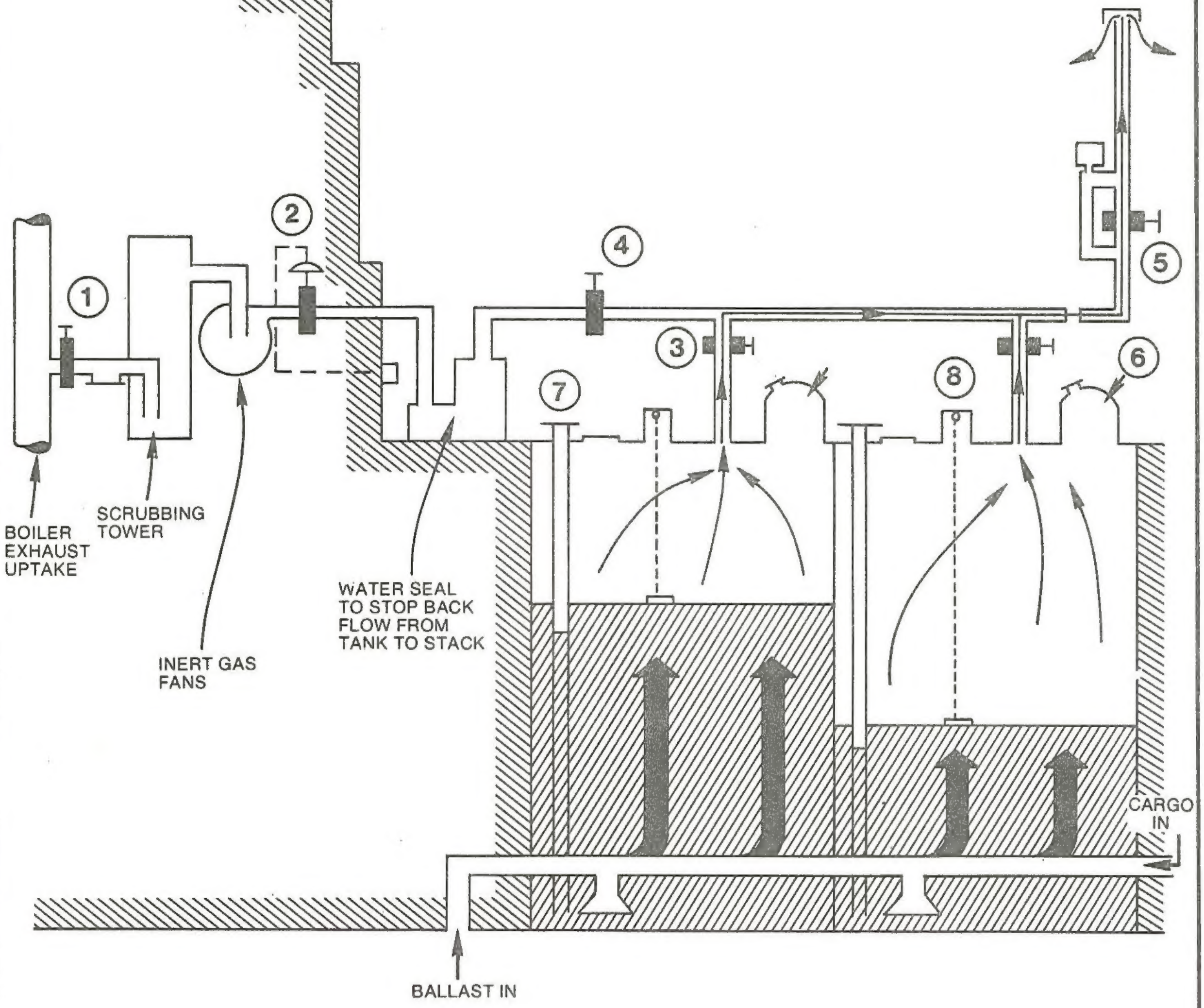
composition is only slightly different; the SO_2 is washed out and the amount of water vapor is reduced. The N_2 and CO_2 concentrations are practically unchanged.

In a tanker carrying crude oil, the risk of a flammable mixture in the cargo compartments is always present. It is essential that the tanker's staff keep the tanks filled with an inert mixture at all times which precludes air from entering.

Operation of inert gas system

Loading port. On arrival at the loading port, the new SOHIO tankers will have all the cargo tanks inerted (Figure A1.1.1.1-1). The tanks will be at a pressure of about 1 to 1.5 pounds per square inch (psi). Before loading commences, the supply of inert gas to the cargo tanks will be shut off. Valves on the mast rises will be opened allowing the system to vent to the atmosphere. Since the SOHIO tankers have a completely segregated ballast system (which is not inerted) the discharge of ballast in no way affects the operation of the inert gas system. (An older, nonsegregated tanker is one which uses cargo tanks, after cleaning, to carry ballast; see below.)

When loading commences, the inflowing liquids will displace gas from the compartments; the gas will escape to the atmosphere through the masthead riser (Figure A1.1.1.1-1). Unless the tanks have been purged (that is, flushed with several charges of inert gas) hydrocarbon vapors will be mixed in with the inert gas, and will escape with the displaced inert gas. The gases will mix with air and, if hydrocarbons are present, will become flammable briefly before they dilute to an overlean condition. Since this would also occur if a tank were ruptured, many masters prefer to purge their tanks during passage to the loading port.



1. Boiler uptake valves closed, inert gas fan stopped.
2. Pressure-control valve shut.
3. Tank gas valve open to appropriate main.
4. Main inert gas stop valve closed on both mains, system off.
5. Mast "riser" valves open to atmosphere.
6. Tank hatch deadweight relief valve in operating position.
7. Purge pipes closed.
8. Mechanical ullaging devices for all gauging.

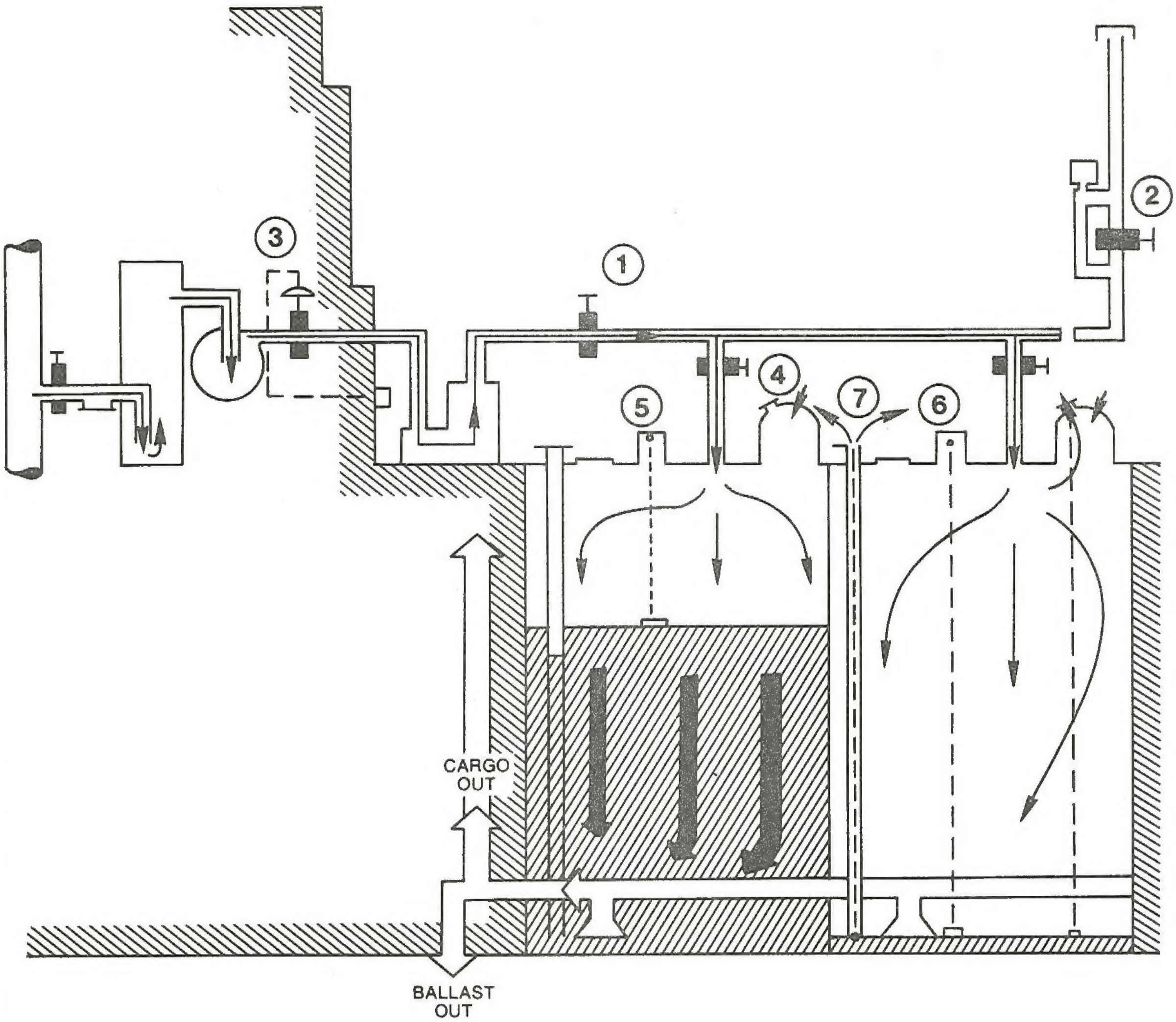
Figure A1.1.1.1-1 Gas displacement when loading cargo

On completion of loading, the riser valves are closed. The inert gas system is started if the gas pressure in the tanks is too low. When the required pressure is reached, the system is shut down.

Loaded passage. The inert gas system will be operated during the passage if inert gas pressure in the cargo tanks falls. It has been found by experience that it is necessary to "top up" the pressure in the tanks about every fourth day.

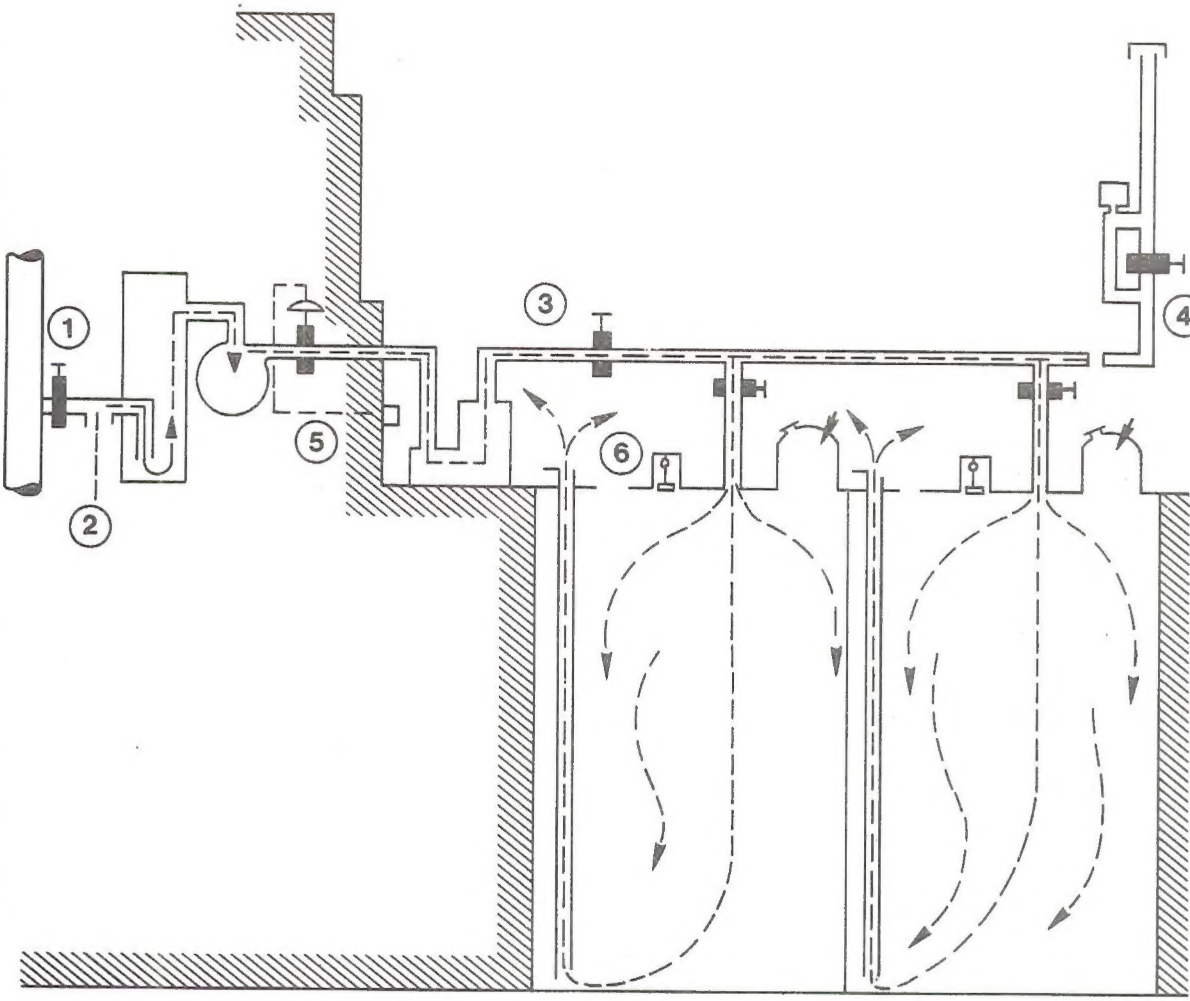
Discharging port. On arrival at the discharge Port, the cargo compartments of the tanker will all have an inert atmosphere of roughly 1 psi. With the new SOHIO tankers, it should be possible to discharge all the cargo with no release of hydrocarbons to the atmosphere. However, on some tankers a small sighting port is normally opened to take soundings in the tanks. This allows the possibility for air to enter the tanks. If reliance would be made on dockside metering for inventory of discharged oil, it would be unnecessary to break the hatch seals. This procedure is part of the proposed SOHIO project plan.

Prior to berthing and when discharging commences, the inert gas system must be fully operative (Figure A1.1.1.1-2). Otherwise, air can enter the compartments; this would encourage early purging of the air and of hydrocarbon vapors in the compartments. As the oil is pumped out of the tanks, the inert gas blowers ensure that the tanks are filled with inert gas. During purging, gases and vapors exit through a pipe which terminates near the bottom of the tank while additional inert gas is pumped in. Therefore, only empty tanks can be purged. Gas-freeing involves additional steps. First, there is tank cleaning (see below); then purging with inert gas; finally, air is blown in to replace the inert gas with fully breathable air (Figure A1.1.1.1-3). Table A1.1.1.1-2 depicts statistical data for the SOHIO tanker fleet.



1. Main inert gas stop valve open on both mains, system in use.
2. Mast "riser" valves closed.
3. Pressure-control valve set for maximum operating pressure during bulk discharge: set for low pressure operation (about 10" W.G.) if sounding manually after all cargo or ballast has been discharged or when finally stripping.
4. Tank gas valve open to appropriate main.
5. Mechanical ullaging device in use when pumping bulk.
6. Mechanical ullaging device (WHESSOE type) unable to record last few inches during stripping if inconveniently positioned in tank.
7. Manual dipping through purge pipe (slight positive outflow due to low pressure operation of pressure control valve).

Figure A1.1.1.1-2 Operative inert gas when discharging cargo



1. Valves on boiler uptakes closed: inert gas fan running.
2. Blank flange removed.
3. Main inert gas stop valve open.
4. Mast "riser" valves closed.
5. Pressure-control valve set for maximum operating pressure.
6. Purge pipes open permitting fast, full flow through tanks being gas freed.

Figure A1.1.1.1-3 Gas freeing, using the inert gas fan

Table A1.1.1.1-2

SOHIO Tanker Fleet Statistics

PARAMETERS	Designation by Weight (tons) 80,000	120,000	165,000
Deadweight	80,569		
Length overall	811 ft	869 ft	899 ft 6 in
Beam	125 ft	136 ft	173 ft
Depth	57 ft	71 ft 8 in	75 ft
Draft	43 ft 7 in	54 ft	55 ft 4 in
Segregated ballast	15,900 tons[a]	42,000 tons	58,780 tons
Speed	17.5 kt	16.8 kt	15.6 kt
Consumption (Sea)	125 tons/day	154 tons/day	188 tons/day
Horsepower	24,000 HP	30,000 HP	26,700 HP
Cargo on Alaska/ West Coast (est.)	78,300 tons	116,200 tons	164,500 tons
Cargo pump capacity	7,094 tons/hr	10,640 tons/hr	14,580 tons/hr
Trips/year (est.) Valdez to Long Beach	25	24.6	23.5

Source: SOHIO Transportation Company of California.

[a] The 80,000 DWT tankers are said to have partially segregated ballast. That is, in the open ocean or coastal waters during stormy weather they must add some ballast to empty cargo tanks. The other ships are said to have fully segregated ballast, or to be "fully segregated."

The volume of gas required for inerting purposes during discharge is considerable. For example, on the new Avondale tankers, the cargo pumps can discharge at about 14,500 tons per hour. This means that about 600,000 cf/hr of inert gas is deviated from the funnel to the cargo tanks. This is approximately 17 percent of the total funnel emission during the discharge cycle (near full power). Because of the large volumes of inert gas necessary for complete purging, this almost certainly would occur after reaching cruising speed unless an emergency arose.

During discharge of cargo, ballast will be taken into tanks. Since the ballast tanks on fully segregated tankers never have cargo or inert gas in them, only air is forced from these tanks.

Ballast passage to loading port

When the tankers leave the discharge Port, all the cargo compartments will be filled with inert gas under pressure. Because the new SOHIO tankers have segregated ballast systems, there is no need for the tankers to undergo tank cleaning in order to have a place to store clean ballast. It is expected that a minimum amount of tank cleaning will be done on the ballast passage, so that there will not be an accumulation of sediment. The washings from this tank will be transferred to a sludge tank. It is probable that this job will not begin until the day after the tanker leaves the discharge Port.

Once the tanker is well clear of Port and back in a sea routine, it is possible that the tanks will be purged with inert gas. After discharge the tanks contain a mixture of hydrocarbon gas and inert gas. If a collision were to occur and the tank ruptured, even though the total mixture in the tank is inert, the outflowing hydrocarbon gas will pass through its flammable range. To reduce this risk, tanks are purged first, third, and fourth steps in (Figure A1.1.1.1-2) to displace all hydrocarbon gas to the atmosphere and to fill the cargo compartments with a totally inert gas. Figures A1.1.1.1-4 and A1.1.1.1-5 identify the differences between an Avondale 165,000-ton segregated-ballast crude oil tanker and the Sun 120,000-ton ecological tanker.

Tanker operations

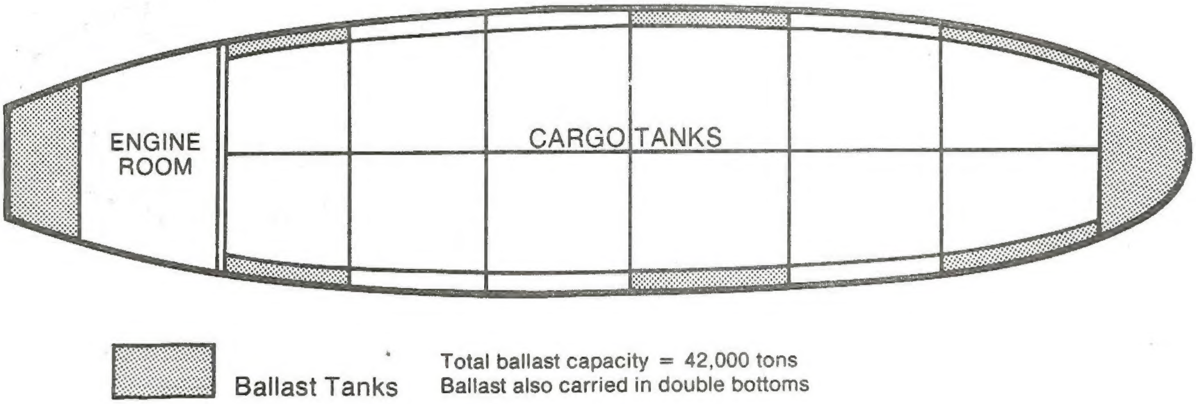
This section emphasizes operational procedures.

Loading. Prior to arriving at the loading port, the ship receives a "Loading Message" giving instructions as to the type and amount of cargo to

DIMENSIONS
Length 869 Ft. Beam 136 Ft. Draft 54 Ft.

BUILDER
Sun Shipbuilding and Drydock Company Chester, Pennsylvania

SEGREGATED BALLAST AND CARGO SYSTEM



Total ballast capacity = 42,000 tons
Ballast also carried in double bottoms

NAVIGATIONAL EQUIPMENT

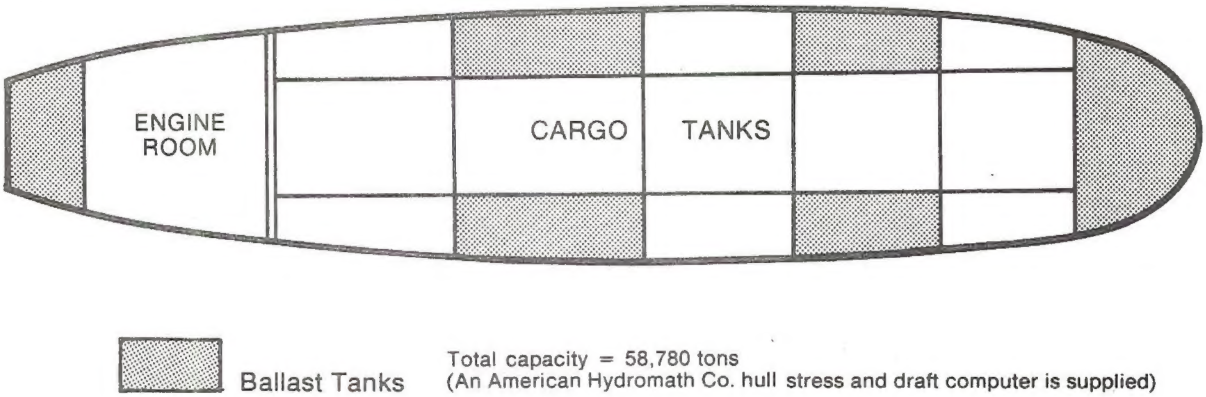
Radio	Worldwide WT & RT Single Side Band equipment.
VHF/UHF	UHF for on board communication. VHF for all marine channels.
Radio Direction Finder	ITT Mackay Automatic Radio Direct Finder.
Weather Facsimile Equipment	ITT Mackay equipment capable of receiving weather forecasts and charts.
Echo Sounders	Two echo sounders and transducers.
Omega	This navigation system is fully automatic and will give a position to within 1 or 2 miles anywhere in the world.
Loran	ITT Mackay type 4207A equipment will receive both Loran A and C.
Radars	10cm and 3cm radar installations by Radio Marine Corp. Two separate units with 16 inch displays.
Anti-Collision Equipment	The Digiplot system can display up to 40 targets and store data on a further 160 targets.
Gyro Compass	Two Sperry Mark 37 compasses plus repeaters.
Log	Modern doppler log equipment.

Figure A1.1.1.1-4 Sun Shipbuilding Company 120,000-ton ecological tankers

DIMENSIONS Length 899½ Ft. Beam 173 Ft. Draft 55 Ft. 4 In.

BUILDER Avondale Shipyards Inc. New Orleans, La.

SEGREGATED BALLAST AND CARGO SYSTEM



Total capacity = 58,780 tons
(An American Hydromath Co. hull stress and draft computer is supplied)

NAVIGATIONAL EQUIPMENT

Radio	Worldwide WT & RT Single Side Band equipment.
VHF/UHF	UHF for on board communication. VHF for all marine channels.
Radio Direction Finder	ITT Mackay Automatic Radio Direct Finder.
Weather Facsimile Equipment	ITT Mackay equipment capable of receiving weather forecasts and charts.
Echo Sounders	Two echo sounders and transducers.
Omega	This navigation system is fully automatic and will give a position to within 1 to 2 miles anywhere in the world.
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Anti-Collision Equipment	The Digiplot system can display up to 40 targets and store data on a further 160 targets.
Gyro Compass	Two Sperry Mark 37 compasses plus repeaters.
Log	Modern doppler log equipment.

Figure A1.1.1.1-5 Avondale Shipyards Company 165,000-ton segregated ballast tanker

be loaded, and its destination. Upon receipt of the loading message the master and chief mate confer and determine how the vessel is to be loaded. After the vessel has arrived at the loading terminal the loading usually occurs as follows:

1. The senior deck officer is in charge of the loading operation; he ensures the following:

-- The ship is adequately moored to the dock.

-- All deck scuppers (drains) are properly plugged.

-- An electric bond is properly established between the vessel and the dock.

-- Drip pans, buckets, and other containment vessels are placed under the cargo connections.

-- A red signal (flag by day and electric light by night) is placed so that it is visible on all sides.

-- A warning sign is displayed at the gangway (no visitors, no smoking, no open lights); also a sign in the ship's radio room warning against use of the radio equipment during transfer.

-- Connecting for cargo transfer.

2. A conference is then held between the senior deck officer and the terminals's person in charge on how the vessel is to be loaded, emergency procedures, etc.

3. Next the master or senior deck officer fills out a Declaration of Inspection stating that all precautions have been taken and that loading may begin.

4. The senior deck officer notifies the person in charge to commence loading cargo.

5. Throughout the loading preparation the senior deck officer supervises to ensure that the loading is in accordance with the loading plan.

6. Toward the end of cargo loading operations, the senior deck officer notifies the person in charge to reduce the loading rate to prevent a pollution incident.

7. The senior deck officer notifies the person in charge to stop loading when the ship's cargo tanks are full. The ship's cargo tanks are carefully sounded and the amount of cargo received is calculated.

8. The cargo lines to the ship are then blown clear of oil, using low pressure air to reduce spillage when the cargo hoses are disconnected.

9. The cargo tank valves on the ship are then shut and the cargo hoses disconnected. The electric bonding is interrupted. Blank flanges are connected to the cargo manifold.

10. The warning signal and warning signs are removed and the deck scuppers unplugged.

11. The master or senior deck officer signs a receipt or manifest for all the cargo loaded, and receives a copy for the ship's records.

12. Finally the ship is loaded sufficiently to sail from the terminal to its port of discharge.

Unloading. The unloading sequence utilized by the tankship closely parallels that of the loading operation, the significant difference being that the ship now discharges cargo to the terminal. The same safety and operating procedures are observed for loading and unloading the ship. Some terminals now require that a skirt be emplaced around the ship prior to all internal and external cargo transfers in port; some terminals merely have the equipment at hand (as in the applicant's proposal), and some terminals give still lower priority to preventing or minimizing impacts from accidental oil spills.

Ballasting. Ballast is by definition any weight carried solely for the purpose of making a vessel more seaworthy. The ballast utilized onboard tankers is in the form of seawater carried in either segregated ballast tanks or in the cargo tanks. Water carried in tanks exclusively dedicated for ballast is termed "segregated ballast." Water carried in cargo tanks that have been thoroughly washed is termed "clean ballast." And water carried in cargo tanks which contain cargo residues is termed "dirty ballast." Approximately one-half of a tankship's life is spent in a ballast condition, and the ballast carried may be as much as one-half the loaded deadweight of the ship. The primary concerns while ballasting a vessel are:

1. The vessel will be stable under all conditions.

2. The vessel will have sufficient ballast to ride well in bad weather.

3. No undue stress will be placed upon the ship (no hogging or sagging).

4. The ship will have sufficient draft and trim to ensure that the propeller is completely immersed.

5. Vibration is prevented or reduced to minimum.

Ballasting usually is begun toward the end of the discharge of cargo. During the ballast voyage ballast is shifted as necessitated by the tank-cleaning operations. As the vessel approaches the loading port it commences discharging ballast until it has the minimum amount of ballast to safely maneuver alongside the dock. Discharge of segregated ballast may be made alongside the dock, but dirty or clean ballast must be discharged ashore to reception facilities.

Tank cleaning. Tankers engage in the activity of tank cleaning for a number of operational reasons. Since tank cleaning is expensive, both in manpower and fuel costs, it is only done when absolutely necessary. Tank cleaning can take place in port or at sea; any number of tanks may be cleaned; after cleaning, the tanks may or may not be gas-freed. The main operational reasons for tank cleaning are (1) to provide space for clean ballast water prior to arrival at loading port; (2) to prepare the ship for the next cargo, if it is different from the previous one; (3) to periodically wash away sludge accumulation, if a minimum washing routing is used; (4) to clean and gas free a tank for maintenance and inspection; and (5) to clean and gas-free before entering a drydock port.

1. A conventional tanker going to a conventional port will take ballast in its cargo tanks. Since there is always some oil clinging to the tank interiors, that ballast is classed as "dirty" and cannot be discharged to the sea direct. If the conventional tanker has a reasonably lengthy voyage before reaching the loading port, selected tanks can be cleaned at sea and filled with clean sea water. The ship's ballast is classified as being clean and can be discharged at the loading berth. The dirty ballast will have settled out to oil and water. The water is discharged to the sea and the oil is retained on board in the slop tank. Cargo is then loaded on top of these slops (the "load on top" technique).

If the voyage time is too short, the ship will probably tank clean alongside the discharge berth, then will take "clean" ballast into the washed tanks.

Ships which have segregated ballast or ships trading to a port such as Valdez do not have to tank clean to get clean ballast. Valdez has dirty ballast reception facilities and thus eliminates the need for normal tank cleaning.

2. Ships carrying refined petroleum products, or ships switching from crude oil to refined products, need to tank clean to avoid possible contamination of cargo. It is often a requirement that they gas-free as well. If there is a sufficient length ballast voyage, this will be done at sea; but if the voyage is short, or if the ship is backloading at a discharge port it will be done in port.

3. Ships on a run such as the Alaskan route, and having segregated ballast tankers, will not have to wash tanks to carry clean ballast. However, every four to six months tanks may need to be washed during the ballast voyage to remove accumulated sludge.

4. Maintenance and inspection will normally coincide with the above; however, in an emergency, the relevant tank or tanks might have to be washed and gas-freed so that the crew can enter them.

5. Tank cleaning and gas-freeing is normally done enroute to the drydock port. The tank washings and sludge have to be discharged ashore at proper facilities before the ship enters dock. Ships with an inert gas system frequently go into drydock without washing tanks if no work in the tanks or on deck is necessary.

6. The most modern tank-cleaning system is called crude oil washing. Some ships are fitted with inert gas systems and fixed tank cleaning

equipment. These systems spray crude oil around the tank bulkheads during discharge of cargo. This technique reduces oil clingage in the tanks and ensures a good discharge, plus clean tanks. Since an inert gas tanker, with the system operating properly, produces no emissions of hydrocarbon vapor during discharge, the crude oil washing system does not cause air pollution. Crude oil washing during discharge will probably be used occasionally on the SOHIO 165,000 and 120,000 DWT ships. This will eliminate the need to water-wash for sludge buildup, or for preparation prior to entering drydock.

Water washing. After the tankship has departed from its port of discharge preparations for tank washing on conventional tankships are begun as follows:

1. The tanks that are to be washed are selected and the relative cleanliness desired is ascertained, and it is ascertained that all dirty ballast or cargo has been removed. For example, a tank that is being gas-freed for inspection is more scrupulously cleaned than a tank washed only for control of cargo sediment.

2. Tank cleaning equipment is readied.

   -- Butterworth plates on the tanks are removed. Ullage openings and tank hatch covers are opened.

   -- If portable tank cleaning machines are used, high pressure rubber hoses are connected to the fire main (the fire main supplies cleaning water to either portable or fixed tank cleaning machines). The cleaning machines are attached to the end of the hose and an electric bonding cable and a safety line are then attached to the machine.

-- The fire main is then charged at the proper pressure and temperature (100 to 165 psig and 120° to 180°F).

-- The eductor system or stripping pumps are aligned and operating to keep the tank as dry as possible while cleaning progresses.

-- The portable cleaning machines are lowered through the Butterworth opening and positioned.

-- The water supply to the cleaning machines (portable or fixed) is allowed to flow.

-- The cleaning machines operate independently, and visual inspection of the tank from above is used to determine the length of time required to complete cleaning. Portable machines must be periodically repositioned to insure proper cleaning.

3. After machine cleaning is halted, the portable machines are removed and steam- or air-driven high capacity ventilating fans are afixed over the Butterworth openings. These fans introduce large amounts of air into the washed tanks. This introduction of air dries the tanks and removes large quantities of hydrocarbon vapor.

4. The deck officer in charge of the tank cleaning usually fitted with a lifeline, enters the tank to inspect for cleanliness. If the tanks are adequately clean, the fans remain in place until the tank is dried. If the tank is not cleaned to his satisfaction, the tank cleaning is reinitiated or localized hand hosing is done.

5. Accumulations of rust and sediment (muck) may be accumulated in the tank bottom. If this is to be removed, men are sent into the tank to remove the muck manually.

6. After mucking operations, the tank may be washed in isolated areas or left as is, according to how clean the tank was to be cleaned.

Gas-freeing. The process described under tank washing is the same one utilized for gas-freeing a conventional tankship cargo tank. The washing cycle for gas-freeing would be much longer, and occasionally the tank is completely flooded after washing and allowed to overflow on deck to displace any entrapped gas pockets. If mucking were required, it would be scrupulously done with additional washing following. In some instances men would be sent into the tank to hand wipe up persistent wet spots. Because of the tremendous amount of work involved, gas-freeing of a tank is done only when necessary; i.e., shipyard period or repairs in the tank. Although this procedure is known as "gas-freeing," the tank is not considered "gas-free" until certified by a marine chemist.

Other safety equipment. Collisions, rammings, and groundings can also cost significant losses, including lives. According to Table 3.1.5.1.2-3, these accidents are much more likely in coastal waters and ports and are of low likelihood in the open ocean.

The SOHIO 120,000 DWT tankers have double bottoms containing segregated ballast to minimize loss of oil through groundings. The SOHIO 165,000 DWT tankers have staggered ballast tanks for protection against ramming accidents (Appendix Figures A1.1.1.1-4 and -5). Ernst Meuller of the Alaska Department of Environmental Conservation testified before the California State Lands Commission on 12 January 1977 that double bottoms add 3 to 4 percent to the cost of a tanker. Other safety equipment on SOHIO tankers includes collision avoidance radar and Loran C navigational aid.

Other equipment (expected on no tankers in the SOHIO trade) that have been proposed are dual rudders and propellers; variable pitch propellers; lateral bow thrusters; a 40 percent boost in horsepower for increased maneuverability; and new concepts in training of pilots, masters and crews, along with higher qualification standards for personnel.

Effectiveness. A study by the Alaska Department of Environmental Conservation found double bottoms to be the most cost effective measure. All safety equipment costs were easily justified when compared with the losses foregone through reduced probabilities of loss of ships and crude oil. Additional modifications of equipment and prodecures would be necessary if results from a tanker study on simulation of supertanker transit in and out of Valdez can be substantiated.

Engineering Computer Optecnomics, Inc. performed the study for the State of Alaska Office of the Pipeline Coordinator (AOPC, 1976). A tanker simulator (analogous to aircraft simulators) was programmed to simulate passage by a 165,000 DWT tanker through Valdez Narrows during expected wind conditions (Section 2.1.1.1 on climate) and perfect visibility. The purpose was to simulate passage by trained and experienced pilots and masters with and without use of tugboats. Up to one-third of all transits ended with the tanker on Middle Rock or the shoreline.

Port Valdez. According to data in the Valdez air quality study prepared for BLM by Environmental Research and Technology, adverse meteorology occurs more frequently at Valdez than at Long Beach. Port Valdez is a fjord experiencing frequent cold dense air descending the mountain slopes and glaciers surrounding the port. Solar effects give rise to a diurnal sea breeze-land breeze under clear or partly couldy skies. There are indications, however, that a thick overcast or heavy cloudiness significantly reduces this effect. Wind conditions are calm at least 10 percent of the time. Wind speeds are 3 miles per hour or less from 40 to 80

percent of the time, with a 60 percent annual average based on data recorded at Valdez Airport from 1963 to 1967.

The emission rates for hydrocarbons during loading in the Valdez study is approximately double the emission rate for ballasting a 70,000 DWT tanker at Long Beach (2,129 lbs/hr, Table 3.1.6.1.2-4). In conjunction with the frequent adverse meteorology, the danger of fire or explosion is serious.

The following text is taken from Day, et al. (1972).

Noninerted vessels loading cargo

> During loading of crude oil, a concentrated layer of hydrocarbon gas forms above the liquid surface of the cargo. This layer rises with the oil with little change in its vertical concentration gradient. The gas expelled from a tank which is initially gas free will consist of air in the early stages of loading, and will remain so until the dense gas layer reaches the vent outlet. The hydrocarbon concentrations in the vent gas will then increase rapidly as the layer itself is vented. Gas expelled from a tank that is not gas free will contain appreciable hydrocarbon concentrations from the start, and, again, these will increase at the end of loading as the surface layer is vented.

Tank atmospheres are within the flammable range for an appreciable part of the loading period (Brummage, 1970).

Inerted vessels loading cargo

> In an initially inerted tank, the atmospheres within the tanks are safe throughout the loading period. The dispersion of vent gases to avoid the formation of flammable hydrocarbon gas/air mixtures about the decks of tankers during loading has been the subject of study by the International Oil Tanker Terminal Safety Group. Provided the recommendations made with regard to the siting of tank vent outlets are followed, the risk of ignition of the diluted vent gases flashing back to the tanks should be minimal. On an inerted tanker, such a flash could not ignite a tank. It will have been noted that the provision of an inert gas system implies closed loading facilities, which in themselves improve the standard of safety.

Permitting at Valdez

According to Ernst Mueller there are no permits to operate separate from the permits to build. Imposition of new restrictions on facilities or operations prior to start-up is unlikely. The current leases will expire in 1979 and conditions on permits can then be expected in order to lessen potential impacts on air quality, safety, and oil spills.

REFERENCES

Appendix A1.1.1.1

Alaska Office of the Pipeline Coordinator. 1976. A Real-Time Simulation Analysis of a 165,000 DWT Tanker Operating Through Valdez Narrows. Draft report prepared by Engineering Computer Optecnomics, Inc.

Day, C.F., Platt, E.H., Telfer, I.E., Tetreau, R.P. 1972. "The Development and Operation of an Inert Gas System for Oil Tankers," RINA TRANS, 114 (1), pp. 33-72.

Bureau of Land Management, 1976. Air Quality Impact of the Proposed SOHIO Tanker Fleet on Port Valdez, Alaska. Report prepared by Environmental Research and Technology, Inc.

Brummage, K.G. 1970. "An Experimental Investigation of the Dispersion of Hydrocarbon Gas during the Loading of Tankers." International Oil Tanker Terminal Safety Group.

International Oil Tanker Terminal Safety Group. International Oil Tanker and Terminal Safety Guide.

APPENDIX A1.1.1.1-A

Tanker Traffic Study

APPENDIX A1.1.1.1-A

TANKER TRAFFIC STUDY

1. INTRODUCTION

This document has been prepared for the Bureau of Land Management under Contract No. YA-512-CT6-181 by Environmental Research and Technology, Inc., for assistance to the BLM in preparation of the Environmental Statement for the proposed SOHIO Transportation Company crude oil transportation system from Valdez, Alaska, to Midland, Texas. This study concerns itself with the composition of the fleet of vessels which will ply the waters between the two Pacific ports and the potential probability of accidents which would impact the environment.

1.1 Project description

The proposed SOHIO transportation system consists of a fleet of crude oil tankers; a berthing facility at Long Beach, California; a storage facility at Long Beach and at Dominguez Hills in the Los Angeles area; 1,026.6 miles of pipeline from Long Beach to Midland, Texas; and a storage facility at Midland. The applicant has proposed that the vessels will transport crude oil from Port Valdez at an average rate of 700,000 barrels per day (bbl/d). These tankers would be unloaded at a proposed facility located at Pier J in the Port of Long Beach. This berthing facility would consist of three piers designed to accommodate vessels ranging from 70,000 dead weight tons (DWT) to approximately 188,000 DWT. (See Chapter 1 for additional information on the project; refer to Appendix A1.1.1.1 for additional information on tankers and tanker operations.)

1.2 Proposed tanker transportation system

Although the terminal and the pipeline are proposed to be constructed as common carrier facilities, the tanker transportation system will be limited to the fleet proposed by the applicant for purposes of determining potential impacts. The SOHIO Transportation Company fleet will consist of a total of 11 vessels (Appendix Tables A1.1.1.1-2 and A3.1.6.1-8):

1. 4 - 165,000 DWT
2. 3 - 120,000 DWT
3. 4 - 80,000 DWT

The 165,000 DWT vessels will be equipped with fully isolated ballast tanks representing 35 percent of the dead weight tonnage of the ship. The ballast tanks will be placed at strategic locations such that the points of most probable impact in the event of a collision are "defended" by the tanks. This defensive ballasting thus acts to prevent oil spillage in the event of a collision or ramming.

As the ballast tanks are completely isolated from the cargo tanks, the ballasting water utilized when the ship is empty does not become contaminated with oil, therefore there is no problem of intentional oil discharge when emptying the cargo holds. Furthermore, when the vessel is being ballasted, hydrocarbon vapors left in the cargo holds after unloading are not displaced and, therefore, air pollution is kept to a minimum. These vessels are also equipped with a cargo hold inerting system. As the cargo is discharged, the hold is filled with gas derived from the scrubbed combustion products from the boiler stacks. This gas contains little or no oxygen and therefore is "inert" with respect to combustion. The inert gas is maintained at a positive pressure in the hold.

The 120,000 DWT vessels are also equipped with 35 percent defensively placed segregated ballast tanks and inerting systems. In addition, these vessels have double bottoms to minimize oil spillage in the event of a grounding.

The 80,000 DWT vessels have only 20 percent segregated ballast, not defensively placed. SOHIO will retrofit the Intrepid and Resolute with an inert gas system prior to their use at Pier J in Long Beach Harbor. The other two ships of this class will also be retrofitted, or other ships with inert gas systems will be substituted.

A list of vessels which qualify for the Alaskan crude oil trade and which can be accommodated in the proposed berthing facility is given in Section 3.

1.3 Topics addressed in this study

The scope of this study is limited to a description of the fleet which might be logically expected to utilize the proposed facility; an analysis of the probability of the oil spills which might be expected from the applicant's fleet; and a discussion of the possible causes of disruption and delay in the flow of crude oil in terms of storage potential during such delays.

2. CONCLUSIONS

Accidental spills

1. Yearly probable volumes of oil spilled are determined by the rare events where the vessel is a total loss. Such an event is estimated to have a 56 percent probability of occurring over a 25-year project lifetime. Two such events over a 25-year period are estimated to have a 9 percent likelihood of occurring and the probability of three such events during this period is estimated at 1.6 percent.

2. If total vessel losses are included, the probable annual volume of oil spilled is 20,189 barrels. This is distributed as follows:

Prince William Sound (Valdez)	6,730 barrels
Prince William Sound to San Francisco (open ocean)	7,333 barrels
San Francisco to San Pedro Bay (coastal waters)	3,883 barrels
San Pedro Bay (Long Beach)	2,243 barrels

These results are in good agreement with those obtained by Socio-Economic Systems for the Port of Long Beach although a somewhat different fleet composition and a quite different methodology has been used.

3. If it is assumed that a total vessel loss does not occur during the project lifetime, the probable annual volume of oil spilled drops to 1,260 barrels, distributed as follows:

Prince William Sound (Valdez)	389 barrels
Prince William Sound to San Francisco (open ocean)	439 barrels
San Francisco to San Pedro Bay (coastal waters)	302 barrels
San Pedro Bay (Long Beach)	130 barrels

4. The use of inert systems, defensive ballast, and a 3-meter separation double hull decreases the spill probability per trip by a factor estimated as 0.54. The three 120,000 DWT tankers which will be equipped with these measures thus can carry approximately the same amount of oil as four nonequipped 80,000 DWT tankers with 64 percent less probability of spill. All vessels in the fleet are similar in terms of spill probability for a given amount of oil delivered except the 80,000 DWT tankers which have approximately 2.5 times the spill probability when measured on this basis. In

the event of a catastrophic loss, however, the smaller tankers may produce less ecological damage. (The decision to retrofit 80,000 DWT tankers with inert gas systems was made after this study was completed. The spill probability per trip would be lower than stated here owing to a decreased probability of fire or explosion.)

5. For the SOHIO fleet, fires, explosion, and breakdown casualties are somewhat more likely than collisions, rammings, and groundings or structural failures in producing a total vessel loss. For accidents in which the vessel is not a total loss, collisions, rammings, and groundings are the most likely casualty categories in producing a spill. For both total losses and less than total losses, however, the probability of a spill from any of these three major casualty categories is within a factor of three of the others (i.e., no totally dominant casualty category is evident).

6. There is no concrete evidence that site-specific factors, including fog, icebergs, or severe storms, increase the risk of accidental spill appreciably above the statistical data base. The reason is that these are recognized or anticipated hazards. For example, it can be argued that operation in fog produces greater caution.

If the number of icebergs, observable by eye or by radar, present in Valdez Arm (Figure 2.1.1.1-1) is less than 10, then the risk of collision is smaller than or comparable to the estimate for rammings in entrances or harbors. When there are between 10 and 100 icebergs observable by eye or by radar and present in Valdez Arm, the probability of collision increases by several orders of magnitude. This is because the separation distances between icebergs becomes comparable to the stopping distance or turning radii of the vessels; therefore, avoidance of a ramming by evasive action becomes difficult or impossible. The probability of ramming

for 100 icebergs in Valdez Arm is an order of magnitude greater than the sum of all types of accidents in all locations (3.7×10^{-3} per voyage).

Moraine or rock-laden small icebergs (growlers) give rise to considerable accident probabilities because they are frequently unobservable by eye or by radar. Even a few (less than 10) can produce an accident probability for ramming which is approximately equal to the sum of the probabilities for all types of accidents in all locations.

7. A tanker-OCS platform collision can be viewed as a special kind of ramming incident. One study (Keith and Porricelli, 1973) found that rammings constituted only 23 of the 175 tanker incidents involving collisions, rammings, or groundings. In general, the probability of a ramming depends upon the number and distribution (i.e., the density) of objects which could be rammed. The probability of a tanker-platform collision can be treated formally as a random-walk problem by analogue with molecular collision theory (see, for example, McDuff, 1974). However, the analogy is probably spurious, since tankers will not execute random-walk motion, especially in the environs of known hazards. Since OCS platforms are in fixed, known locations, and could be further equipped with a variety of navigation aids such as lights, they may actually constitute a navigational benefit, and thereby reduce the risk of grounding, for example.

Assessment of this point should take into account the belief that the results obtained in this study are generally conservative (i.e., tend to overestimate the number and volume of accidental spills). The origin of this conservatism, if it exists, results from the use of world tanker fleet rather than U.S. fleet accident statistics.

The probability per voyage of grounding in Valdez Arm and Valdez Narrows is currently estimated to be approximately 10^{-4}. This estimate is based on English Channel data and has attempted to take into account the variations in channel width and the presence of Middle Rock.

The potential for grounding in Valdez Arm and Valdez Narrows appears to be comparable to that for grounding in other ports used by large tankers (Finnart, Milford Haven, Europoort).

The only condition identified that is unique to Valdez, which may present significant grounding potential, is the presence on occasion of extremely high wind speeds. However, these high wind speeds are associated with clearly recognizable synoptic weather conditions and thus these periods could be forecast. It does not appear that significant delays or disruptions would occur from halting tanker traffic during anticipated high wind speed conditions, since the synoptic conditions responsible are not expected to last for more than about one day.

Operational spills

8. Based on historical data, the probable rate of operational spills is 9 spills/year (68 barrels per year) at both Port Valdez and at the Port of Long Beach. The actual rate for the SOHIO fleet is expected to be lower because of new pollution prevention regulations and terminal design at Port Valdez. Volume spilled should also be less than 68 bbl/d; a significant factor at Long Beach is the commitment by the Port of Long Beach to full skirting of tankers during all unloading and fuel transfer operations.

Tanker availability

9. There are sufficient Jones Act tankers available for the transport of the projected 700,000 barrels of crude oil from Valdez to Long Beach. Sufficient capacity exists to limit the vessels utilizing the proposed facility to those which would not significantly contribute to the existing air pollution problem in the Long Beach area.

10. If the risk of collisions with icebergs is controlled by suspending traffic when icebergs are in the channel, then delays of at least three to four days are anticipated, as estimated from historical records of iceberg incidents in Valdez Arm. If indications that Columbia Glacier (Figure 2.1.1.1-1) is becoming unstable are verified, then a greater frequency of substantial numbers of icebergs in Valdez Arm may be anticipated. Since the present storage capacity in Port Valdez is about seven days production, application of this countermeasure could require curtailment of pipeline flow.

Moraine or rock-laden small icebergs (growlers) are of particular concern, since they are not observable either by eye or by radar. A possible countermeasure is a sonar capability aboard the tankers.

If tanker traffic is to proceed in the presence of icebergs, then appropriate structural modifications to the bow of the tanker (e.g., increased structural rigidity or collapsible members) would reduce oil spill probabilities.

3. PROBABLE COMPOSITION OF THE ALASKA FLEET

3.1 Statutory limitations on the potential Alaskan crude oil transport fleet

The composition of the potential fleet which can be utilized to transport crude oil from Valdez, Alaska, to "lower 48" ports is limited by statutory as well as by physical considerations. By Federal statute, all vessels transporting goods between U.S. ports must be constructed in U.S. facilities and owned by U.S. citizens. Commonly called the Jones Act, this statute effectively limits the potential fleet under consideration for this study.

The vessels will be plying coastal waters which may fall under the control of the states of Alaska and California. In addition, tankers employed in the Alaskan crude oil trade visiting ports in the state of Washington may fall under the jurisdiction of that state.

Jones Act limitations

The Jones Act states:

> "No merchandise shall be transported by water or by land and water, on penalty of forfeiture thereof, between points in the United States including districts, territories, and possessions thereof embraced with the coastwise laws, either directly or via a foreign port, or for any part of the transportation, in any other vessel than a vessel built in and owned by persons who are citizens of the United States. . . ."

Furthermore, vessels which have received construction subsidies or are receiving an operating subsidy are constrained from operating in domestic trade. However, if construction subsidies are repaid, the vessel may be utilized for domestic purposes.

Waivers to the Jones Act may be obtained; the conditions for such waivers are severely containing. The principal basis for waiver is based on need for purposes of national defense. A list of tankers available which meet the Jones Act requirements is given in Section 3.2

State of Alaska regulations

In June, 1976, the State of Alaska Legislature passed the "Alaskan Vessel Traffic Regulation Act." The act requires that owners of all tankers larger than 40,000 deadweight tons (DWT) pay an annual "risk charge."

This fee is to be deposited in a special fund to pay for oil spill prevention equipment, personnel, and operations. The magnitude of this fee will depend on whether the vessels are, or are not, equipped with specific safety features such as (see Appendix A1.1.1.1):

1. Electronic navigation systems (required by the Act).
2. Electronic collision avoidance systems (required by the Act).
3. Double hulls.
4. Segregated ballast.
5. Gas Inerting systems.
6. Lateral thrusters.
7. Auxiliary propulsion systems.
8. Redundant radar systems (required by the Act).

According to the act, vessels not equipped with lateral thrusters, controllable pitch propellers and redundant boilers, or other backup system equipment will be required to have a tug escort while in Alaskan waters. The Alaskan State Department of Environmental Conservation has been delegated the authority for implementation of this act which becomes effective 1 July 1977. The legal validity of this act may be challenged. It is anticipated that legal action will await the outcome of a suit (Arco vs. Evans) which challenges a similar statute passed by the state of

Washington. A present Federal lower court has declared the Washington law invalid. However, the matter is still in litigation. Furthermore, the definition of "Alaskan Waters" will, in all probability, be a matter of dispute. Strict interpretation of the statute would require vessels to pick up tug escort outside of Hinchinbrook Island on their way to Port Valdez unless they are equipped with the required features. Such a journey would be in excess of 70 miles under escort and would be costly. The Alaskan Department of Environmental Conservation must draw up the required regulations. It is empowered, under the statute, to exempt vessels from the tug escort provision in certain ports when vessel safety will not be reduced by the absence of the tug escort.

State of Washington

Although this project does not directly impact this state, its "Oil Tanker Law" may affect the overall Alaskan fleet. This law requires maneuverability equipment on all tankers in excess of 40,000 DWT and bans all tankers larger than 125,000 DWT from entering Puget Sound. This law is presently being challenged in the courts.

State of California

This state has no passed legislation specifically regulating tankers in state coastal waters. However, the air pollution regulations of the South Coast Air Basin may apply to tankers while docked. If so, all tankers using Pier J in Long Beach Harbor would be required to have fully segregated ballast and an inert gas system. A ruling from the California State Attorney General is required.

3.2 Projected Alaskan crude oil tanker fleet

As discussed above, the vessels available for the Alaskan crude oil trade are limited to those which meet the Jones Act requirements or which are capable of meeting these requirements if construction subsidies are repaid or if operational subsidies are suspended.

The following list of vessels meet the Jones Act requirements. It must be emphasized that this list may contain omissions; because of the short time available for this report it was not possible to determine whether any of these vessels meet the requirements of the Alaskan Tanker Act. Only vessels which can be accommodated in the proposed terminal facility are considered.

Owner/Operator	Vessel Name	Year Constructed	Size (DWT)	Segregated Ballast %
SOHIO	SOHIO Intrepid	1971	80,700	20
SOHIO	SOHIO Resolute	1971	80,600	20
SOHIO	Joseph D. Potts	1970	81,000	20
SOHIO	Name Unknown	1970	80,700	20
SOHIO	Prince William Sound	1976	118,000	36
SOHIO	Sun Hull #668	1977	118,000	36
SOHIO	Sun Hull #669	1977	118,000	36
SOHIO	Avondale Hull #2295	1978	165,000	36
SOHIO	Avondale Hull #2296	1977	165,000	36
SOHIO	Avondale Hull #2297	1979	165,000	36
SOHIO	Avondale Hull #2298	1979	165,000	36
Exxon	Exxon Houston	1964	71,500	15
Exxon	Exxon Baton Rouge	1970	75,600	15
Exxon	Exxon Philadelphia	1970	75,600	15
Exxon	Exxon San Francisco	1969	75,600	15
Exxon	Exxon New Orleans	1965	71,500	15
Arco	Arco Juneau	1974	120,600	21
Arco	Arco Anchorage	1973	120,600	21
Arco	Arco Fairbanks	1974	120,600	21
Arco	Arco Prudhoe Bay	1971	70,400	9
Arco	Arco Sag River	1972	70,400	9
Mobil	Mobil Arctic	1972	129,000	18
Chevron	Chevron California	1972	70,200	9
Chevron	Chevron Hawaii	1973	70,200	9
Chevron	Chevron Mississippi	1972	70,200	9
MOC	Overseas Juneau	1973	120,500	20
Manhattan Tankers	Manhattan	1965	114,700	
(This vessel was highly modified to determine the feasibility of passage through Arctic waters.)				
Union	Sansinina II	1971	70,500	9
Vantage	Vantage Defender	1959	71,000	4

Note: Thirty-five percent segregated ballast is considered full segregation; that is, if segregated tankage represents approximately 35 percent by volume of crude oil capacity, the ship could carry sufficient segregated ballast to maintain stability in rough open seas.

The following ships are either under construction or are planned. All planned vessels will have 35 percent segregated ballast.

Owner	Shipyard Hull Number	Estimated Completion	Size (DWT)
Shell	Nassco #405	Spring 1978	188,500
Shell	Nassco #406	Summer 1978	188,500
Arco	Nassco #408	Fall 1979	150,000
Arco	Nassco #409	Summer 1980	150,000
MOC	Nassco #398	Summer 1977	89,500
MOC	Nassco #399	Fall 1977	89,500
MOC	Nassco #400	Spring 1978	89,500
MOC	Nassco #401	Spring 1978	89,500

The capacity of the tabulated Jones act fleet is 3,960,700 deadweight tons. This is equivalent to 29,555,700 barrels of oil. If one makes the assumption that all of the vessels have the same cruising speed, they will each be capable of making 23 round trips between Valdez, Alaska, and Long Beach, California, each year giving a total crude oil transport capacity of 680 million barrels per year. The Alaska pipeline throughput is anticipated to be 1.2 million barrels per day or 438 million barrels per year. Thus, there appears to be adequate transport capacity for all of the oil.

Of the stated capacity, 2,854,300 deadweight tons of shipping is in vessels having a segregated ballast of 20 percent or greater. This represents a shipping capacity of approximately 492 million barrels per year. These ships would not give rise to the principal hydrocarbon air pollution problem of the South Coast Air Basin described in Section 3.1.6.1.2. A potential mitigating measure would therefore be to stipulate that no ballast may be

taken in the Long Beach port area into tankers other than those having at least 20 percent segregated tank capacity. The South Coast Air Quality Management District has stipulated that only fully segregated tankers would be allowed to use the Long Beach terminal (Section 4.2.2). The proposed capacity of 700,000 barrels per day for the terminal represents an annual rate of 256 million barrels. Currently constructed fully segregated tankers have insufficient capacity (174 million barrels). With inclusion of tankers that are planned or under construction capacity is adequate (352 million barrels).

4. IMPLEMENTATION OF PORT VALDEZ-LONG BEACH TANKER SHIPMENTS

The oil will come through the trans-Alaska pipeline at the rate of 1.2 million bbl/d after the initial startup period. The trans-Alaska pipeline terminates at Valdez in a 8.5 million barrel storage facility. This facility is connected to four berthing areas. One of these berths can accommodate tankers up to 120,000 DWT and the other three berths can accommodate tankers in the range of 70,000 to 250,000 DWT. Upon loading the crude oil the tankers will proceed via Valdez Arm, through Prince William Sound and the Hinchinbrook Narrows to the open sea. They will then take a straight line course to a point approximately 20 miles off of Point Conception, California. From Point Conception, the vessels will follow the coast line. It is most probable that the tankers will go through the channel between the mainland and the "Channel Islands" off of southern California. The actual route for each vessel, however, will be determined by the ship's master and will be based on existing sea and meteorological conditions.

Upon arrival outside of the Port of Long Beach entrance (Queen's Gate), the ships will be brought to the Pier J berthing area under tug escort. They would discharge the crude oil into the tank terminal to be located on the pier. This terminal would consist of six tanks providing approximately 3.7 million barrels of storage capacity. The oil would than be transported to

the inland (Dominguez Hills) terminal which would have a storage capacity of approximately 1.2 million barrels. The oil not distributed in the southern California area would then be shipped via the proposed pipeline to the Midland, Texas, terminal for further distribution. The Midland terminal would have a storage capacity of approximately 2.1 million barrels.

4.1 Possible causes of disruption or delay

Disruptions to the proposed transportation system can be classified into the following categories:

1. Major mechanical failures in the linear portion of the system (pipeline or terminal).

2. Disruptions caused by labor disputes or by long-term inclement weather conditions. These are not related to the mechanical integrity of the system.

3. Disruption due to "bottlenecks" in various portions of the system.

If there is a major mechanical failure in some portion of the linear system the complete transportation system could be forced to slow, and eventually, shut down. Such failures would include major pipeline ruptures, failure of a critical pump station, or a major oil spill which would preclude any vessel from entering the berthing facilities. In the event of such a failure the complete system, as proposed by the applicant, could be shut down with no severe impact on future restart. The temperature of the crude oil in the line is between 93° and 135°F. Shutdown would permit the oil to cool. However, the routing of the line is such that the cooling would not prevent restart of the flow when the disrupting condition has been rectified. There would be, however, significant excess energy consumed during the restart due to the increased viscosity of the oil. If the disruption would cause a lengthy period during which no oil could flow, the

oil could be carried to the Panama Canal and transferred to the Gulf Coast via this route. The oil from those ships too large to pass through the Canal would have to be lightered into smaller ships on the west side of the land to make the passage to the final eastern seaboard port.

The second category of disruptions would tend to shut down the whole system. It is anticipated that the vessels in the fleet will be capable of steaming through most weather conditions. However, the vessels will be forced to slow down, especially in the Gulf of Alaska. In the event of long periods of inclement weather, it is possible that complete shutdown of the system could occur. The storage facility at Valdez is large enough to store approximately seven days of crude oil at full production. If such a period were to last longer than seven days (plus whatever days allowed by storage available in ships already in port) the Alaska pipeline would have to be shut down. On the other hand, if the inclement weather occurs south of the Gulf of Alaska, ships could circumvent the storm by rerouting.

Disruptions due to labor disputes could cause the entire oil transportation system to be shut down. Although the specific bargaining units having jurisdiction over the proposed trading route have not been identified at this time; there is a long history of labor disputes on the West Coast. These disputes have lasted well over 20 days. In the event of such a dispute, the management of Alaska Pipeline Co. would have to take necessary steps to ensure that the line could be restarted. During the winter months, the oil could cool to such an extent that restarting would be very difficult, if not impossible. Potential measures would be to fill the line with distillate products which have a pour point sufficiently low to assure restart. In the event the labor dispute is confined to the proposed pipeline route, crude oil could be shipped via the Panama Canal if economically feasible to the applicant.

Bottlenecks can occur from mechanical failures at the terminals and from normal inclement weather. If there is a storm at sea, the ships tend to

bunch up as they slow down in the storm. This bunching will require ships to idle at one of the two ports. The applicant has provided data which indicate that the storage facilities at both Valdez and at Long Beach will be sufficient to take care of the majority of bottlenecks without causing significant variation in the flow of crude through the pipelines. The number of berths proposed for construction is based on an average utilization no greater than 45 percent. This figure is based on experience gained by terminal operators which indicates that higher average utilization leads to serious bottlenecks. In the event of untoward delays due to bottlenecks, there appears to be sufficient shipping available that "spot" charters would be readily available within relatively short times. These chartered ships will effectively act as a buffer until the bottleneck is remedied.

Similar reasoning has been applied in determining the storage requirements on shore. The applicant has shown that by considering normal delays, some mechanical failure, and average times required at berth, the storage facilities proposed will have a "safety factor" of approximately 2.

5. ANALYSIS OF OIL SPILL PROBABILITIES ASSOCIATED WITH THE SOHIO TANKER TRANSPORTATION SYSTEM

5.1 Introduction

Figure 5-1 presents the sources of oil pollution resulting from tanker transportation. ERT has attempted to quantify the risk of oil spills from all of the known sources for the SOHIO, Valdez-Long Beach tanker fleet. Estimates of spills are presented on a yearly basis for the transport of 700,000 bbl/d. Separate discussions are provided on casualty-related spills and operations-related spills because of the different nature of the causes involved. In addition, possible measures for reducing the risk of oil spills are presented.

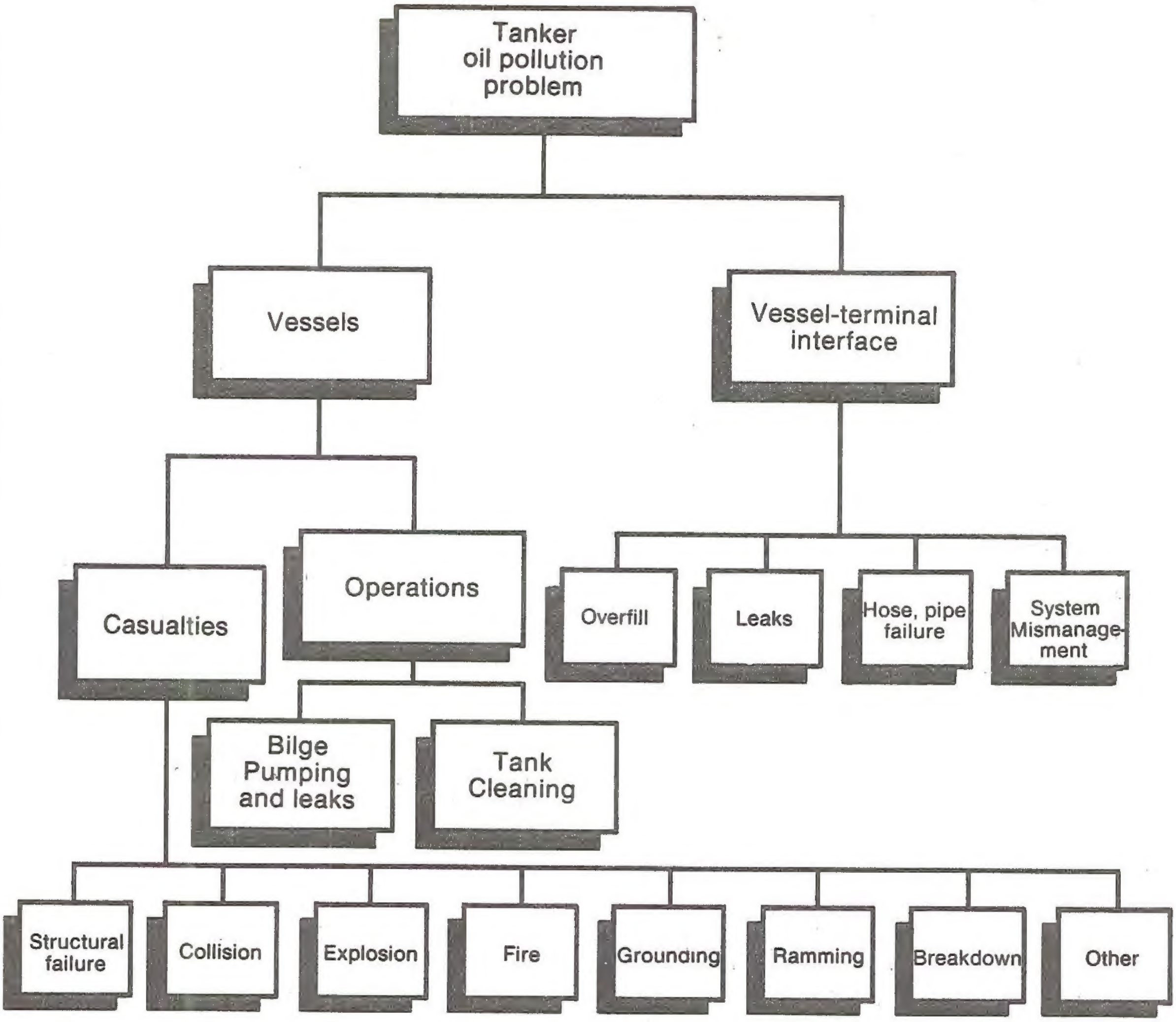


Figure 5-1 Possible sources of oil pollution during tanker operation

5.2 Operational spills

Operational sources of oil spills include all of the "noncasualty" related sources shown in Figure 5-1. Normal tanker operations have, historically, included intentionally discharging oily wastes during bilge pumping, tank cleaning and ballasting operations. The quantities of oil discharged during these operations may be large, and this takes place generally while the ships are at sea. However, new regulations, operating procedures, and equipment are reducing or eliminating most of the intentional operating discharges of oily wastes from U.S. tankers. Accidental spills of cargo oil and fuel oil occur while loading and/or unloading at terminals. Some accidental spills are the result of equipment failures, but most are the result of human error. (See Appendix A1.1.1.1 for a discussion of tanker operations and equipment.)

5.2.1 Intentional discharges

Intentional discharges of oil and oily wastes during tank cleaning and ballasting operations have historically been the largest source of oil pollution from tankers (Keith and Porricelli, 1973). However, tankers loading oil at the Port Valdez Alyeska terminal will be required to operate without intentional discharges of oil. Alyeska will provide facilities at Port Valdez for receiving and treating oily wastes and ballast from cargo tanks, and each shipmaster will be required to sign an affidavit to the effect that he has not discharged oil at sea during his voyage to the terminal. Alyeska will confirm this affidavit by an inspection of the ship's oil record log book.

5.2.2 Accidental discharges

Unintentional discharges of oil result from tanker operations in loading and unloading cargo and fuel at terminals. The standard estimate for oil spills resulting from terminal operations is one-half barrel spilled per million barrels handled. The Port of Long Beach has a better than average record, with less than one-tenth barrel spilled per million barrels handled. During 1971 and 1972, the U.S. Coast Guard reported 624 vessel-related harbor spills of 1,000 barrels or less of crude oil. The average spill size was 7.5 barrels and the amount of oil handled during the time period was 1,412 million barrels (Devanney and Stewart, 1974). The spill rate from this data is 3.3 barrels per million barrels handled, which is well above the rates previously cited. Part of the discrepancy in spill rate may be traced to the inclusion of casualty-related harbor spills in the 1971-1972 Coast Guard data and the inclusion of data on small vessels such as tank barges which have a relatively large number of cargo transfers.

A U.S. Coast Guard study of oil cargo transfers (Leotta and Taylor, 1973) found that the quantity of oil transferred has little bearing on the probability of an accidental discharge, since it is at hookup and disconnect that most discharges occur. This indicates that operational spills would be more accurately related to transfer operations or vessel calls than to volume of oil handled. Milford Haven, a large volume, fixed-berth terminal in the United Kingdom, has reported one spill for about every 60 ship calls and an average spillage rate of 1.8 barrels per million barrels handled (Devanney and Stewart, 1974). Adjusting the number of spills per vessel call to reflect the higher spillage rate indicated by the 1971-1972 Coast Guard data for the United States yields a rate of one spill for about every 35 vessel calls. This estimate seems to be most applicable to the SOHIO, Valdez-Long Beach fleet, while maintaining the conservatism of the Coast Guard data.

The SOHIO fleet is expected to make approximately 300 vessel calls per year (Tables A3.1.6.1-8, -9, and -10) at each port (Valdez and Long Beach). Assuming one spill every 35 vessel calls and an average spill size of 7.5 barrels, each port will be expected to experience nine spills, amounting to a total of about 68 barrels each year.

5.2.3 Time and site-specific factors

The previous section indicates that it is not possible to accurately estimate unintentional operational spills using the available data. In fact, the historical U.S. data base is probably not applicable now because of changes in the Pollution Prevention Regulations. The Pollution Prevention Regulations (33 CFR 154-156) became effective on 1 July 1974. These regulations were issued under the authority of the Federal Water Pollution Control Act, which declared that "It is the policy of the United States that there should be no discharges of oil or hazardous substances. . . ." Part 155 of the Pollution Prevention Regulations requires cargo oil spill containment on tank vessels, fuel oil spill containment on all vessels over 100 gross tons, oily waste and slop tanks, slop tank pump out arrangements and oil-water separators (Brown and Robinson, 1975). The regulations are quite specific in requiring spill containment devices under loading headers and spill containers under or around tank vents, fill lines, and overflows. These regulations are expected to be quite effective in reducing operational spills, since the largest single source of those spills is tank overflows. Data from the Port of Long Beach for the period 1962 to 1969 indicate that about 40 percent of all tank ship spills resulted from overfilling tanks (Putman, 1971).

Further reduction in the number of oil spills can be expected at the Port Valdez, Alaska, terminal because of its design. Transfer to and from the tankers will be through steel loading arms -- no hoses will be used. Each loading arm is equipped with a flow control valve which is instrumented to (1) limit the amount of loading pressure on the ship's manifold to that

which the master has set as a safe maximum working pressure, (2) limit the maximum flow in any arm to the desired rate, but prevent the rate from exceeding a predetermined safe maximum allowable rate, (3) block the flow within seven seconds with a command for emergency close from either the dock operator or the Operations Control Center, and (4) block the flow automatically should a tanker commence to close a valve creating a rate of pressure increase above a preset value (Welbaum, 1973). This design should stop spills from broken hoses (8 percent of tankship spills at Long Beach [Putman, 1971]).

5.2.4 Mitigating actions

Most operational spills are caused by personnel failures such as overfilling tanks, incorrect operation of valves, and transfer of hoses which have not been adequately drained. Almost all oil spills caused by personnel failure can be eliminated by better training, adequate supervision, and improved vigilance on the part of the operators. Training is fairly easy to arrange either "on-the-job" or by simulated exercises. Supervision is also easily achieved. Ensuring constant vigilance is more difficult to achieve. One promising approach to increasing worker vigilance during transfer operations has been the observation of transfer operations by uniformed Coast Guard officers (Leotta and Taylor, 1973). This approach was used in Puget Sound in 1971 and resulted in a 60 percent reduction in transfer-related spills.

5.3 Casualty-related oil spills

Casualty-related oil spills occur much less frequently than operational spills. However, casualty-related spills may be quite large, making them of considerable environmental importance. We have attempted to quantify the risk of a casualty-related oil spill specifically for the SOHIO Valdez-Long Beach fleet based on historical data. A qualitative discussion is provided on site-specific factors such as fog, storms, and icebergs that might affect the probability of casualty-related spills.

5.3.1 Definition of accident and spill factors

In the discussion which follows, it is convenient to consider three different accident and spill probabilities:

1. The probability P per trip of a tanker accident.

2. The probability Q of a spill given that an accident has occurred.

3. The probability S that the vessel is a total loss, given that an accidental spill occurs.

The probability S is introduced so that catastrophic losses may be distinguished, where the volume of oil released should depend on the volume of oil carried by the vessel, from smaller (and more frequent) accidental spills which may be characterized by an average volume of oil released independent of vessel size.

The probabilities P and Q are based on data contained in the report by Socio-Economic Systems (SES, 1976) with some modifications to reflect the specific characteristics of the SOHIO fleet and the Port Valdez to Long Beach environment. Worldwide casualty data for 1969-1970 from Porricelli et al. (1971) and the U.S. Coast Guard (1972) was used together with probability data from the Oceanographic Institute of Washington (1974). The probability S and the associated spill sizes, also worldwide for 1969-1970, are based on Keith and Porricelli (1973).

The probabilities P, Q, S are parameterized in the following analysis by accident type (index i, defined in Table 5-1), accident location (index j, defined in Table 5-2), and by the vessel type (index n, defined by the SOHIO fleet composition and shown together with other fleet characteristics in Table 5-3).

Table 5-1

Accident Types

PARA-METER	Casualty	Description
i = 1	Collisions	Two vessels strike (ship to ship casualty).
2	Rammings	A moving vessel strikes a fixed object, such as a pier or an offshore drilling platform (ship to object casualty).
3	Groundings	A moving vessel strikes the ocean bottom, obviously where the water is not deep enough for the ship to continue moving.
4	Breakdowns	Some mechanical failure aboard ship leads to an accident.
5	Fires and explosions	A fire or explosion aboard ship causes an accident.
6	Structural failures	A ship's structure fails in such a way that an accident results.

Table 5-2

Accident Locations

PARA-METER	Location	Description
$j = 1$	Piers	Vessels in contact with a wharf, pier, dock, quay, etc.
2	Harbor	Vessels within the confines of a harbor, bay, river, etc.
3	Entrance	Vessels at the entrance to a harbor, bay, river, etc.
4	Coastal	Vessels within 50 nautical miles of shore (1 nautical mile = 1.15 land miles = 1.85 kilometers).
5	Sea	Vessels outside the 50-nautical-mile limit.

Table 5-3

SOHIO Fleet Composition

For Delivery of 700,000 bbl/d to Long Beach

PARA-METER	Vessel Type (n)	Number (N)	Annual Visits to Long Beach, Each Vessel (T)	Loaded Oil Volume (v)
n = 1	SOHIO-owned, inerted with fully segregated defensive ballast 165×10^3 DWT	4	20.5	1.19×10^6 barrel
2	SOHIO-owned, inerted with fully segregated defensive ballast and double hull 120×10^3 DWT	3	21.33	0.84×10^6
3	SOHIO-owned, partially segregated ballast 80×10^3 DWT	4	22.25	0.57×10^6
4	Not SOHIO owned, fully segregated defensive ballast and double hull 120×10^3 DWT	3	21.33	0.84×10^6

The probability per year of an accidental spill where the vessel is a total loss is given by:

$$P_t = \sum_n T_n N_n \sum_i S_i \sum_j P^n_{ij} Q^n_{ij} \qquad (5\text{-}1)$$

for either the Valdez to Long Beach or the Long Beach to Valdez trip. (See Table 5-3 for additional definition of symbols.)

The amount of oil spilled for this type of loss on the Valdez to Long Beach trip is computed from:

$$V_t = \sum_n v^n T_n N_n \sum_i S_i \sum_j P^n_{ij} Q^n_{ij} \quad (5\text{-}2)$$

(Note that various indices have been suppressed in writing equations [i.e., S_i might be written as S^n_{ij}, etc.]. This is a natural outcome of the fact that as one looks at more and more specific events, the data becomes increasingly sparse.)

In dealing with rare events, all analysts face a similar problem. If the definition of the data set is broad and it contains a large number of events, the statistics may be good, but the events considered may not closely resemble the event of interest. On the other hand, if the definition of the data set is narrow, the events considered may be directly pertinent to the event of interest, but may be insufficient for statistical analysis.

The combination of superscripts and subscripts occurring in the above equations reflects the degree to which the data has been aggregated (due to sparseness) in the literature previously cited. As the development proceeds, it will, in addition, be necessary to further aggregate certain i and j values.

Continuing the discussion, the probability per year that an accidental spill not involving a total vessel loss will occur on the Valdez to Long Beach to Valdez round trip is represented by:

$$P_{1t} = 2 \sum_n T_n N_n \sum_{ij} (1-S_i) P^n_{ij} Q^n_{ij} \quad (5\text{-}3)$$

If the average spill size is v_i the amount spilled is:

$$V_{1t} = 2 \sum_{n} T_n N_n \sum_{ij} v_i (1-S_i) P^n_{ij} Q^n_{ij} \qquad (5\text{-}4)$$

The factor of 2 occurring in equations (5-3) and (5-4) is due to the fact that T_n is the number of one-way trips. The data set defining v_i is assumed to be an average to which both loaded and ballasted conditions contribute, and no distinction is therefore made within the summations between the Valdez to Long Beach and Long Beach to Valdez trips.

Equations (5-1 to 5-4), which involve several matrix multiplications, form the basis for the analysis which follows. In this analysis, summations on indices i, j, or n are occasionally not performed in order to present results by accident type, location, or vessel type.

5.3.2 Data used in the analysis

Table 5-4, based on Macduff (1974), shows the matrix P^n_{ij} of accidents per voyage decomposed by type of accident and location.

Table 5-4

P^n_{ij} Accidents per Voyage[a]

World Tanker Fleet 1969-1970

PARA-METER	Casualty	j=1 Pier	2 Harbor	3 Entrance	4 Coastal	5 At Sea
i = 1	Collisions	0.08	0.45	0.26	0.25	0.04
2	Rammings	0.45	0.17	0.06	0.03	0.01
3	Groundings	0.02	0.35	0.56	0.19	0.01
4	Breakdowns	0.01	0.03	0.03	0.08	0.33
5	Fires and explosions	0.17	0.04	0.01	0.03	0.14
6	Structural failures	0.02	0.01	0.02	0.01	0.61

[a] All valves are to be scaled by the factor 10^{-3}.

Table 5-5 shows how this data is altered by the specific composition of the SOHIO fleet in the following ways:

1. There is known to be a strong correlation between tanker age and probability of structural failure. Accordingly, the probability of structural failure has been reduced by a multiplicative factor of 12.5/19.66 = 0.62 which is the percent (relative to total for all ages) of the total structural failures in the 1969 to 1970 period due to tankers zero to four years old divided by the percent of total number of tankers four years or younger in this period (Keith and Porricelli, 1973). All of the SOHIO fleet is less than four years old.

2. Of the 34 fire and explosion incidents noted in Keith and Porricelli (1973), nine explosions occurred with the tanker in ballast. Of these nine incidents, five occurred during tank cleaning and seven

(or possibly eight) occurred at sea. Since there are no known cargo tank explosions for tankers with an inerting system, the at-sea fire and explosion probability was decreased by a multiplicative factor of (total less tank cleaning)/total = 29/34 = .85 for those tankers in the SOHIO fleet with such a system (n = 1,2). This is felt to be a very conservative reduction since a number of additional fire and explosion incidents for which there is insufficent information might also have been prevented by an inerting system.

3. A vessel traffic system (VTS) has been proposed for Port Valdez (U.S. Coast Guard, 1975). The Port of Long Beach also has the equivalent of a Coast Guard VTS, although privately installed by the contract pilot service. Consequently, collision, ramming, and grounding probabilities in pier, harbor, and entrance locations are reduced by a factor of 0.75, a nominal value used in Federal Power Commission Environmental Impact Statements concerned with LNG tanker traffic (Federal Power Commission, 1976).

Table 5-5

P_{ij}^{n} Accidents per Voyage[a]

Estimates for the SOHIO Fleet

PARA-METERS	Casualty	j=1 Pier	2 Harbor	3 Entrance	4 Coastal	5 At Sea
i = 1	Collisions	0.06	0.34	0.20	0.25	0.04
2	Rammings	0.34	0.13	0.04	0.03	0.01
3	Groundings	0.015	0.26	0.42	0.19	0.01
4	Breakdowns	0.01	0.03	0.03	0.08	0.33
5	Fires and explosions	0.17	0.04	0.01	0.03	0.12 (n=1,2) 0.14 (n=3,4)
6	Structural failures	0.012	0.006	0.012	0.06	0.38

[a] All valves are to be scaled by the factor 10^{-3}.

In Table 5-6, the probabilities in Table 5-5 have been aggregated by summing i=1-3, i=4-5, and j=1-3. The purpose in doing this is to achieve consistency with the sparser data shown in Tables 5-7 and 5-8 (SES, 1976) which give the probability that an oil spill will occur following a tanker accident.

Table 5-6

P^n_{ij} SOHIO Fleet[a]

Aggregated i and j Values from Table 5-5

PARA-METER	Casualty	j=1-3 Pier, Harbor, Entrance	j=4 Coastal	j=5 At Sea
i=1-3	Collisions, rammings, groundings	1.81	0.47	0.06
i=4-5	Fires, explosions, breakdowns	0.29	0.11	0.45 (n=1,2) 0.47 (n=3,4)
i=6	Structural failures	0.03	0.06	0.38

[a] All values are to be scaled by the factor 10^{-3}.

Table 5-7 gives the probability of spill following a tanker accident based on data from the world fleet for 1969-1970. Table 5-8 shows how this data is altered by the specific composition of the SOHIO fleet in the following ways:

1. In the data tabulated by Keith and Porricelli (1973) collisions and rammings (CR) represent 105/175 = 0.60 of all collision, ramming, and grounding incidents (CRG) resulting in a spill. The four SOHIO 165 x 10^3 DWT tankers (n = 1) have defensive, segregated ballast around approximately 70 percent of the ship perimeter. Accordingly, the likelihood of a CRG resulting in a spill is reduced by a multiplicative factor of (1-CR)+CR x 0.7 = (1-0.6) + 0.6 x 0.7 = 0.82 (1-CR represents the fraction resulting from groundings; CR the fraction resulting from collisions and rammings). This estimate is thought to be conservative, since the vessel can be maneuvered prior to a collision or ramming in order to utilize that part of the perimeter which has defensive ballast.

2. The six SOHIO and non-SOHIO 120,000 DWT tankers (n=2,4) have both defensive ballast and a double hull. The double hull, which has a separation distance of 3 meters, is taken to reduce the likelihood of a spill resulting from grounding by a multiplicative factor of 0.06. This is based on the data for groundings shown in Figure 5-2 where 2 out of 33 incidents shown involved a depth of penetration in excess of 3 meters (Federal Power Commission, 1976). (Figure 5-2 does exhibit some correlation of depth of penetration with vessel beam but the data are sufficiently scattered that an estimate without consideration of vessel size seems warranted.) As a result of these factors, the spill probabilities for CRG and n=2,4 can be reduced by a multiplicative factor of (1-CR) x .06 + CR x (Defensive Protection) = (1-0.6) x 0.06 + 0.6 x 0.7 = 0.44.

3. The SOHIO 80×10^3 DWT vessels have neither defensive ballast nor double hulls. For n = 3, therefore, the spill probabilities are unchanged from Table 5-6.

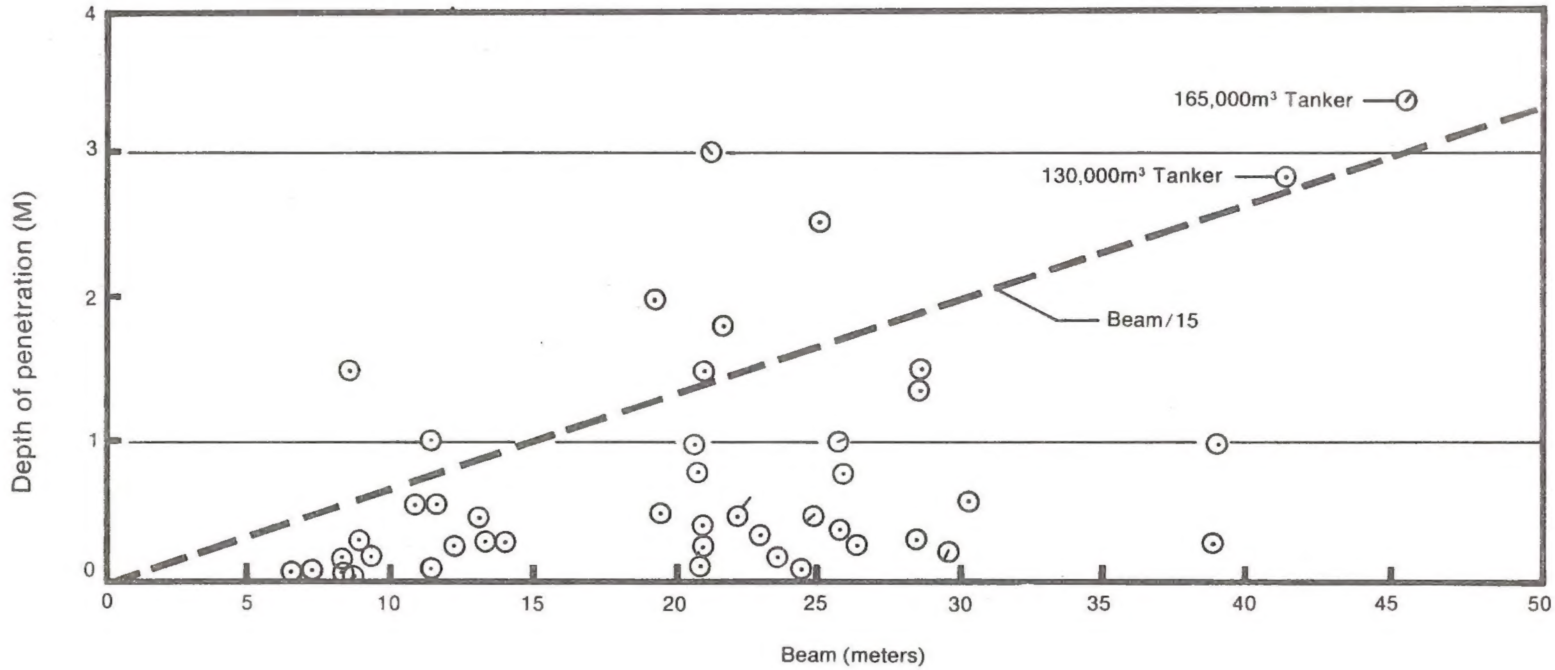


Figure 5-2 Vertical extent of grounding damage versus tanker beam

Table 5-7

Q^n_{ij} Probability of an Oil Spill After a Tanker Accident

World Tanker Fleet 1969-1970

PARA-METER	Casualty	j=1-3 Pier, Harbor, Entrance	j=4 Coastal Waters	j=5 At Sea
i=1-3	Collisions, rammings, and groundings	0.138	0.379	0.133
i=4-5	Fires, explosions, and breakdowns	0.247	0.182	0.078
i=6	Structural failures	0.900	0.250	0.201
	Total	0.178	0.341	0.148

Table 5-8

Q^n_{ij} Probability of an Oil Spill After a Tanker Accident

SOHIO Fleet

PARA-METER	Casualty	Piers, Harbors, Entrances	Coastal Waters	At Sea
i=1-3	Collisions, rammings, and groundings	0.11 n=1 0.06 n=2,4 0.14 n=3	0.31 n=1 0.08 n=2,4 0.38 n=3	0.11 n=11 0.04 n=2,4 0.13 n=3
i=4-5	Fires, explosions, and breakdowns	0.25	0.18	0.078
i=6	Structural failures	0.90	0.25	0.20

The remaining data required to utilize Equations 5-1 through 5-4 is shown in Table 5-9 (Keith and Porricelli, 1973). The probability S_i is the ratio of number of total ship losses to all spill incidents for each casualty type. All of the structural failures resulting in total loss shown in Table 5-9 are in the loaded condition. (The 124,462

barrels shown thus correspond to a loading of 9.6 bbl/DWT for the median value of 13,000 DWT in the 1969-1970 tanker fleet.)

Table 5-9

Probability of Total Vessel Loss S_i and Spill Volumes

World tanker Fleet 1969-1970

CASUALTY	Total Loss Number	Total Loss S	Average Volume V bbl	All Losses Number	Less than Total Losses Average Volume V
Collision, ramming, grounding	10	0.057	47,457	175	3,709
Fire, explosion, breakdown	9	0.243	32,289	37	507
Structural	11	0.216	124,462	51	11,859

In reality, of course, the probability of total loss should also depend on the specific fleet composition. To a certain extent, this has been dealt with in treating the spill probabilities Q^n_{ij}. There is one area, however, that requires specific mention, namely that the probability of total loss due to collisions or rammings probably decreases with increasing vessel size. The reason is that the lateral extent of damage inflicted (except for raking type collisions) should represent a decreasing fraction of the total vessel length with increasing vessel size (Federal Power Commission, 1976).

However, a similar statement is probably not true concerning groundings. Groundings represent 40 percent of the total losses in Keith and Porricelli's data (1973) and may be a particular hazard in the incompletely charted waters of Prince William Sound. (Both of the reported tanker accidents in Prince William Sound are groundings.) For these reasons, we have not altered the value of S_i for collisions,

rammings, and groundings from that obtained from Keith and Porricelli (1973).

5.3.3 Calculation of accident probabilities using site specific features of Port Valdez

Examples of attempts to relate accident probabilities to site and vessel specific characteristics, such as density of ship traffic or other obstacles, channel width, vessel size, turning radius, stopping distance, etc., can be found in the literature (Macduff, 1974, Tetra Tech, 1976; USACE, 1974; SAI, 1975). All previous work utilizes the same basic method, which is discussed in this section as a preliminary to estimating grounding and iceberg collision probabilities in Port Valdez.

Begin by writing the accident probability over a voyage of length S as

$$P_A = P_B P_C S \tag{5-5}$$

where P_B is the probability per unit distance that a blind randomly navigated vessel would suffer an accident of the type of interest; P_C, Macduff's (1974) "causation probability," represents the effect of ordinary care and competency on the part of the Master/Pilot and crew in reducing the risk of accident. It should be noted that P_A is the probability of an accident which may or may not involve an oil spill.

The utility of Equation 5-5 is that all site specific features such as channel width, density of vessels or other objects, etc., enter explicitly in the calculation of P_B. For example, as given by Macduff for a vessel of (straight line) stopping distance T in a channel of uniform width C, the probability of grounding per unit distance along the channel for a blind pilot is

$$P_B = \frac{4T}{\pi C} \qquad (5\text{-}6)$$

when $T \leq C/2$

Equation 5-6 is not actually used in the subsequent analysis because of the restriction $T \leq C/2$ and the requirement that the channel be of constant width. Subappendix A contains the derivation of Equation 5-6 as well as its extension to arbitrary values of T/C. Section 5.3.3.2 contains a description of the graphical analogue to the analytic derivation contained in Subappendix A which is actually used in the analysis of grounding in Port Valdez. This graphical method was developed to treat a channel of variable width and include the effect of the presence of Middle Rock. The reader is referred to the example in Subappendix A for further explication as to what is meant by a "blind randomly navigated vessel."

In Section 5.3.3.1 a similar method, based on the concept of a blind randomly navigated vessel, is used to determine the probability P_B for encountering a randomly spaced field of obstacles (for this purpose, assumed to be icebergs).

The probability P_C must be obtained from accident data, in this case that provided by Wheatley and Johnson (1973) as analyzed by Macduff (1974) and by Tetra Tech (1976). For the English Channel/Manches with S = 18.42 miles (16 nautical miles), the values of P_C shown in Table 5-10 were obtained. These values are given for various types of accidents over a five-year period both before and after the installation of a traffic separation scheme in June, 1967. P_C for grounding has been obtained using grounding data for P_A in conjunction with Equations 5-5 and 5-6 with S and C both equal to 16 nautical miles and T equal to 1.62 nautical miles (assumed to be 20 average ship lengths). Macduff attributes the negligible effect of the vessel traffic separation scheme on P_C for grounding to the fact that the

Channel/Dover Straits area has central shoals and sand bars throughout, and suggests that it can be considered as two separate passages.

TABLE 5-10

Values of P_C Obtained From References

ACCIDENT TYPE	Reference[a]	Without Traffic Separation	With Traffic Separation
Grounding	M	8.41×10^{-6}	7.65×10^{-6}
Head-on collision	TT	1.72×10^{-4}	1.04×10^{-6}
	M[b]	2.81×10^{-5}	1.71×10^{-5}
Crossing collision	TT	1.09×10^{-5}	9.30×10^{-6}
	M[b]	6.02×10^{-6}	5.16×10^{-6}
Overtaking collision	TT	1.45×10^{-4}	1.38×10^{-4}

[a] Reference M is (Macduff, 1974); Reference TT is (Tetra Tech, 1976).

[b] Values shown for purposes of comparison only.

The values for collisions involving two ships are based on the analysis of the Wheatley and Johnson data by Tetra Tech. In this case P_B is calculated from the formula

$$P_B = \eta_o \sigma_c \frac{Y}{S} \qquad (5\text{-}7)$$

where η_o is the density of ships for which a collision would be of the type of interest (crossing, parallel, or antiparallel traffic) and σ_c is the collision cross section based on ship dimensions. σ_c is calculated in a frame of reference in which the "target" vessels are stationary; this introduces the factor Y/S, where Y is the distance traveled in this frame of reference. The reader is referred to Subappendix B for details of the method.

Certain assumptions which should be mentioned enter into the calculation of P_C values for collision. Tetra Tech assumes that 90 percent of the traffic in the channel is passing through the straits and that 10 percent is crossing traffic. An average vessel speed of 13 knots is assumed except for overtaking collisions where a relative speed of 6 knots is assumed.

In determing P_C for crossing collisions, it is necessary to divide the Tetra Tech values by 2 since their analysis for crossing collisions (but not overtaking or head-on collisions) improperly counted the number of ships involved (two per event) rather than the number of events (data in Table 5-10 is reproduced directly from the references).

After dividing the Tetra Tech values for crossing collisions by 2, these values are seen to be comparable to those obtained from Macduff. The Tetra Tech values for head-on collisions are considerably larger than those obtained from Macduff because Tetra Tech (correctly) take the target vessel cross section to be based on ship beam rather than length.

5.3.3.1 Risk of iceberg collisions

For stationary "targets" with $V_i = 0, \theta = \frac{\pi}{2}$ Equation (B-1) of Subappendix B gives

$$P_B = \eta_o (b_i + b_t) \qquad (5\text{-}8)$$

Since growlers ($b_i \leqslant 30$ feet) are the objects of interest b_i can be neglected compared to the tanker beam b_t (136 feet for a 120,000 DWT tanker). Equation 5-8 then becomes:

$$P_A \simeq P_c \eta_o b_t S \qquad (5\text{-}9)$$

Suppose icebergs only occur in the shipping lanes a fraction F of the year and then with an average separation

$$d = \sqrt{n_o}$$

Equation 5-8 may be rewritten as:

$$P_A \simeq P_c F S \frac{b_t}{d_2} \qquad (5\text{-}10)$$

Figure 5-3 shows the extent of icebergs reported by the M.V. Glacier Queen and Alaskan Ferry Bartlett between 8 June and 5 September 1976, as reported by Post (1977). From this figure, estimate S at about 10 miles. During the interval reported in Figure 5-5 (90 days) icebergs were observed in the shipping lanes on 23 days. As shown in Figure 5-4 the 90-day reporting period appears to have included the onset of icebergs drifting into Valdez Arm but not the conclusion subsequent to 5 September when observations ceased. In 1975 icebergs were photographed extending well into Valdez Arm on 8 October (Mays, 1977). Because of these facts, estimate F as

$$F \simeq \frac{23}{90}\,\frac{(90+30)}{365} = 0.084 \qquad (5\text{-}11)$$

Now as to the value of P_C. It is apparent that when the iceberg spacing d is small compared to the vessel turning radius (about 1 mile) or stopping distance (about 2 miles) no evasive action will be possible, and one must have P_C approximately equal to 1. On the other hand when the iceberg spacing is large compared to these vessel parameters we may expect that P_C may be about 2×10^{-4} based on the values for overtaking collisions shown in Table 5-10. (Overtaking collisions are chosen rather than head-on collisions or crossing collisions because they most closely resemble the closing speeds and target sizes of interest here.) It is to be noted that for the English Channel (Macduff, 1974) average ship separation is 4 nautical miles, average stopping distance is 1.6 nautical miles, and average turning

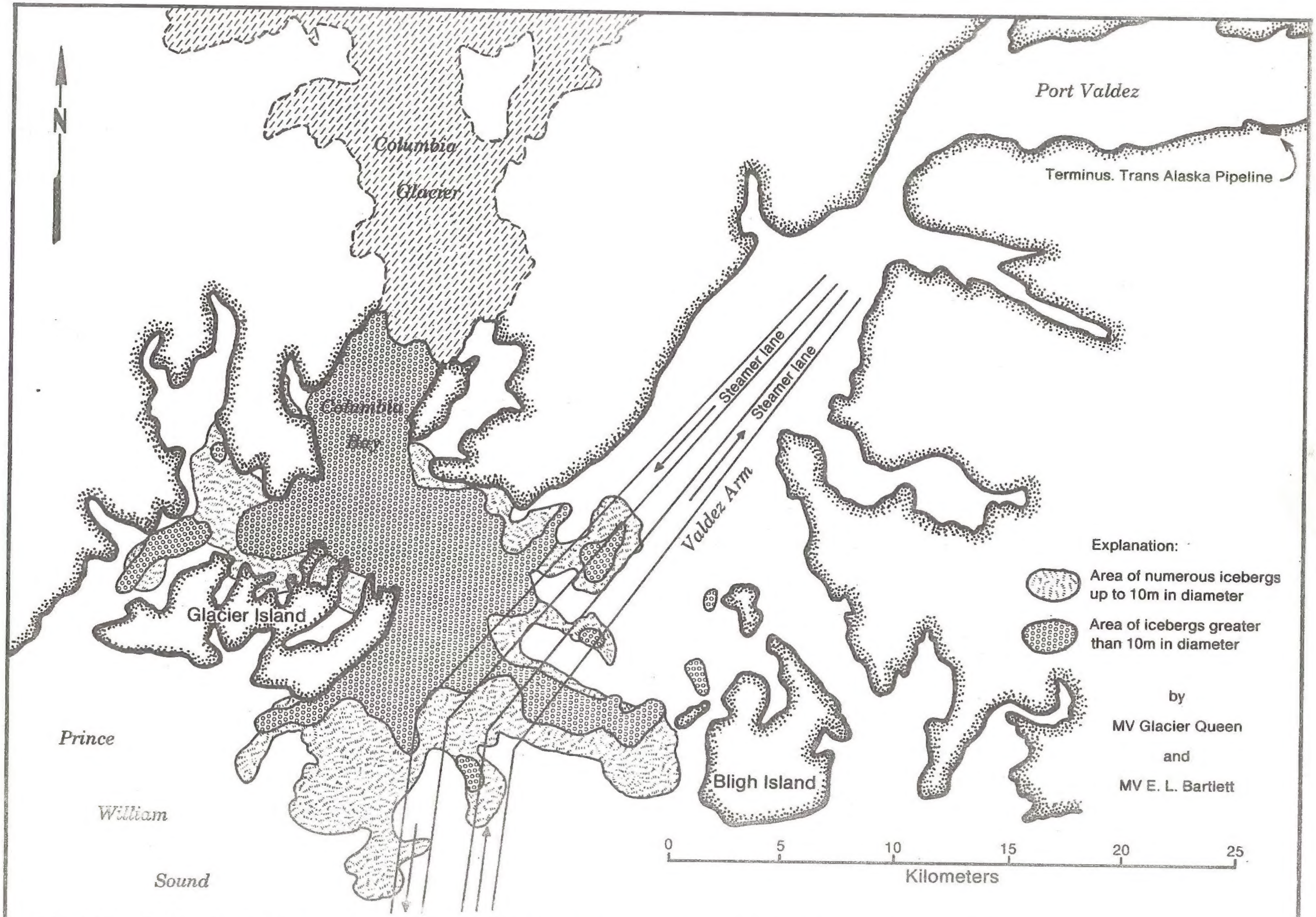


Figure 5-7 Location of reported icebergs, June 8 to September 5, 1976

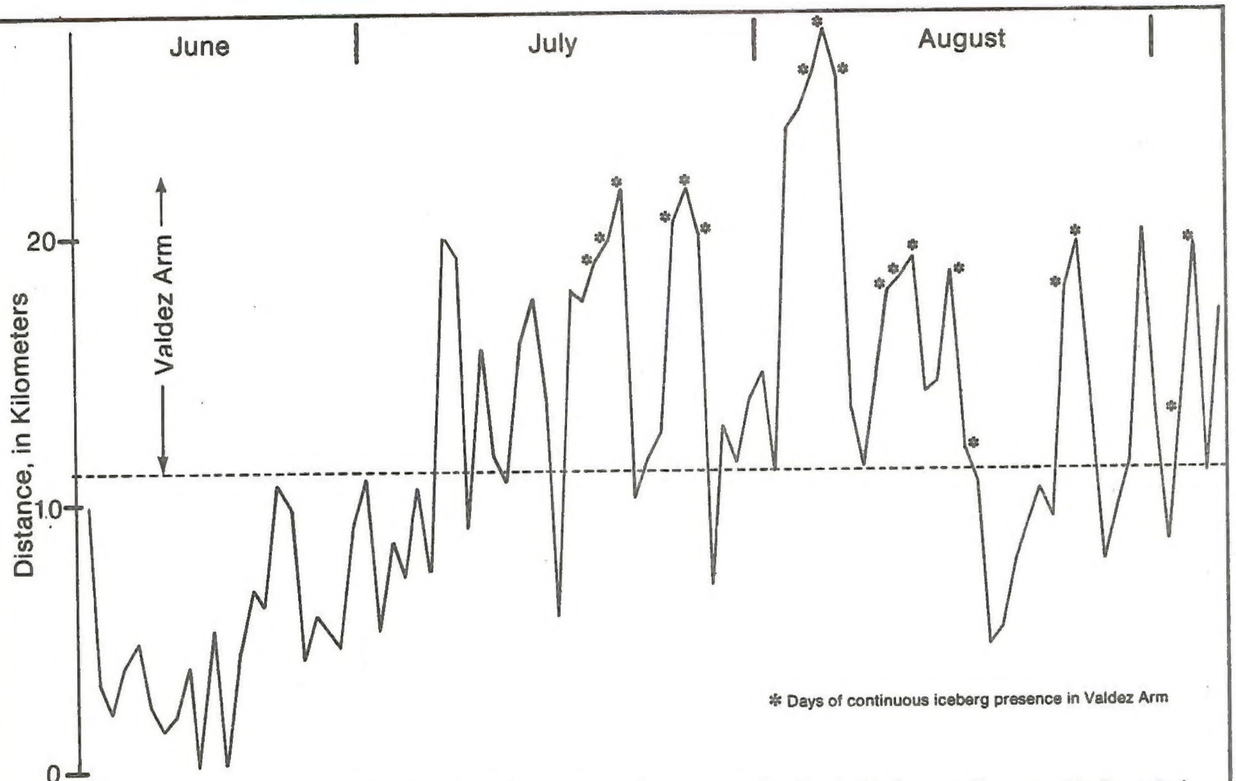


Figure 5-4 Distance icebergs observed drifting from Columbia Glacier, June 8 to September 5, 1976

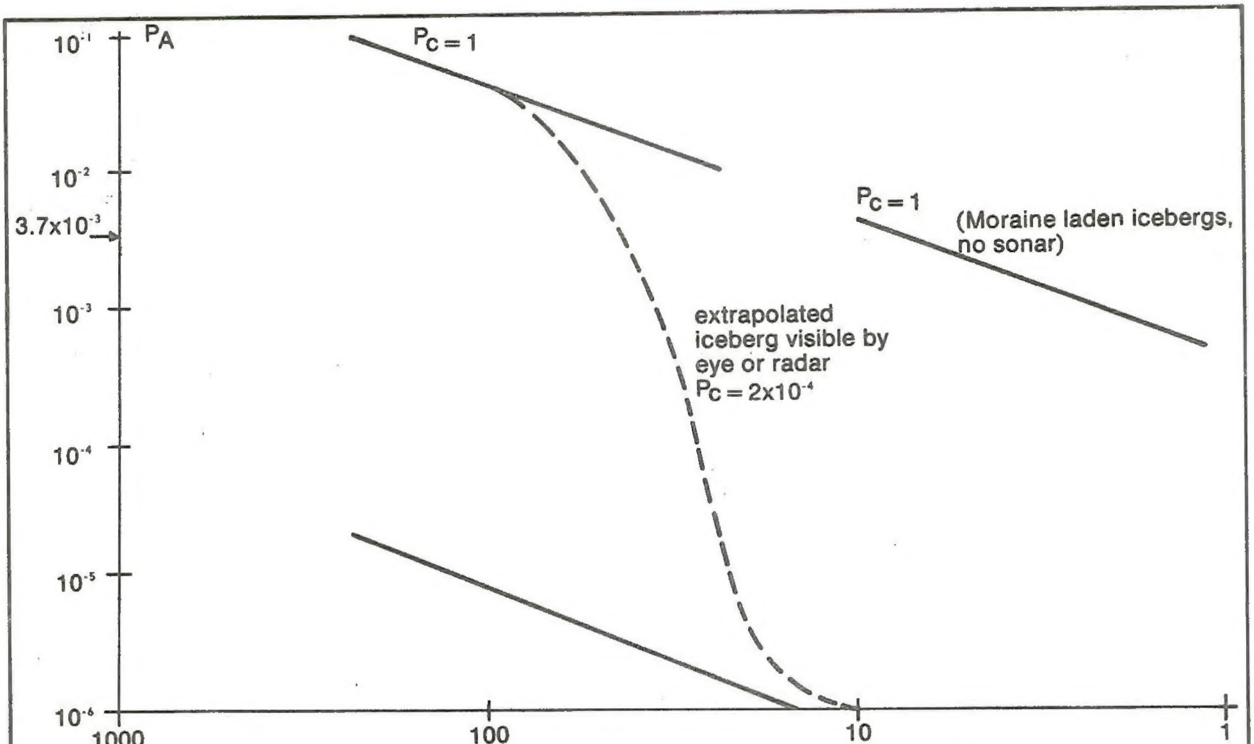


Figure 5-5 Accident probability P_A (per voyage) for collisions with icebergs

radius (estimated to be six vessel lengths) is 0.5 nautical miles. For the SOHIO tankers proceeding through Valdez Arm at, say, 11 knots, estimate stopping distance T at about 2 miles and turning radius of about 1 mile. Figure 5-5 shows P_A versus N, the total number of icebergs in the shipping channel, for a 120,000 DWT tanker assuming a channel width y of 5 miles (corresponding to the shipping lane width for both lanes plus the separation zone, near the entrance to Columbia Bay). In deriving these results the relation $Nd^2 = yS$ was used so that Equation 5-10 becomes:

$$P_A \approx P_C F N \frac{b_t}{y} \qquad (5\text{-}12)$$

Figure 5-5 shows the rapid increase in accident probability which occurs when the number of icebergs in the channel exceeds about 10. The probability P_A (about 3.7×10^{-3}) indicated in Figure 5-5 corresponds to the total probability for all types of accidents (fire, explosion, ramming, etc.) in all locations (pier, harbor, at sea, etc.) as derived for the SOHIO fleet using equation 5-1 and 5-3. Clearly if vessels pass through Valdez Arm when more than 10 icebergs are present in the shipping lanes, collisions with icebergs will be the dominant accident probability. It is worth noting that large numbers of icebergs have been observed in Valdez Arm. Photographs taken by L. Mayo of USCG on 8 October 1975 show what is estimated to be on the order of 100 clearly identifiable icebergs in the shipping lanes.

In constructing the curve labeled $P_C = 1$ (moraine-laden growler, no sonar) in Figure 5-5 ERT has assumed a growler awash so that it is not detectable visually or by radar. Icebergs have in fact been observed in Valdez Arm which are so encumbered by rock as to barely float with little or no visible surface above the water (Post, 1977). The assumption is that a vessel would be truly blind in such a collision and hence $P_C = 1$. For one such object in the shipping lane, P_A is about 4×10^{-4}, a value approximately equal to our previous estimate

for rammings in all locations (pier, harbor, entrance, etc.) per voyage.

5.3.3.2 Grounding in Valdez Arm

5.3.3.2.1 Generalization of the geometrical probability result to variable channel width

As previously discussed in Section 5.3.3, the geometrical probability of striking the walls of a channel of uniform width is expressed by

$$P_B = \frac{4T}{\pi C} \qquad (5\text{-}13)$$

where

T = the stoppping distance of the vessel

C = the channel width

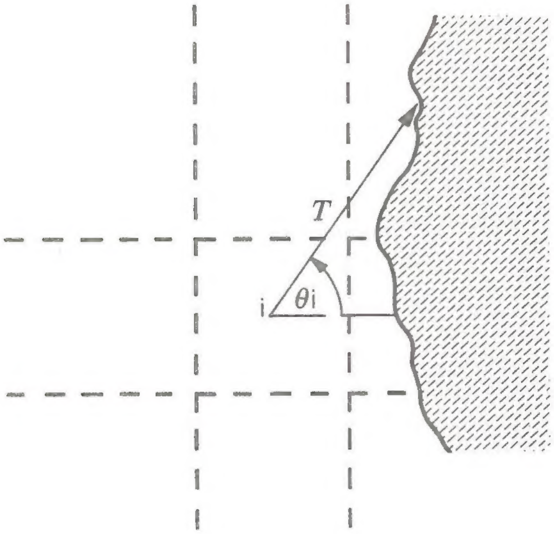
P_B = the probability of grounding per unit path length

For stopping distances on the order of or greater than the channel width, the geometrical probability goes to unity (Subappendix A). For the present application, the probability of a vessel grounding during transit through Valdez Arm and Port Valdez is required. Because the channel width varies greatly along this route, a generalization of Macduff's relationship suitable to irregular channels is required. This has been achieved for the present study in the following manner:

1. Apply a uniform square grid to the total channel area of transit with grid size smaller than the assumed stopping distance of the tanker.

2. For each grid box, compute the total angular extent (between 0° and 180° in the "forward" direction), for

which sections of the channel wall, or obstacles within the channel, lie within a circle drawn from the center of the grid box with radius equal to the stopping distance. See figure below.



This may be interpreted as follows: $\theta_i/180$ is the probability that a tanker starting from the center of cell i and traveling (blindly) at random in the forward direction would strike the side of the channel, or a terrain obstacle in the channel, within its stopping distance T.

3. If it is assumed that the tanker may be within any cell i with equal probability, then the average geometrical probability of grounding, per trip through the channel, is given by the expression

$$P_B = \frac{1}{N} \sum_{i=1}^{n} \theta_i/180 \qquad (5\text{-}14)$$

where the summation extends over all N grid cells (i = 1...N).

It can be shown that this result agrees well with Macduff's in the limit T/C << 1 for a channel of uniform width.

For application to the present problem, the total channel has been defined to include that portion of Valdez Arm lying portward of the line joining Point Freemantle with the western tip of Busby Island (but excluding the waters of Galena Bay and Jack Bay), Valdez Narrows, and Port Valdez. A uniform 1-mile square grid was superimposed upon a 1:79,000 scale nautical chart of Valdez Arm (Chart 16708, U.S. Department of Commerce). The tanker stopping distance (T) was taken as 2 miles. For each cell, the angle subtended by the channel sides or shoals less than 10 fathoms in depth was computed for this stopping distance. (In a few instances, the center of a grid cell lay more than 2 miles from the nearest edge of the channel; for these cells, of course, θ_i was taken to be 0.) A total of 60 cells was used to grid the area described.

The graphical analyses and computations were done with and without Middle Rock. In the absence of Middle Rock, the overall average geometric probability of grounding was found in the above manner to be 0.454; with Middle Rock included, the probability increased only very slightly, to 0.457. The reason is that, for the cells which include Valdez Narrows, the geometrical probability of grounding is already nearly unity due to the large stopping distance (T = 2 miles) relative to the width of the Narrows (about 1 mile). Thus, adding Middle Rock cannot increase the overall geometrical probability appreciably.

Requiring tug escorts through the Narrows and/or Coast Guard regulations may result in reduced tanker speeds (e.g., 7 to 8 knots) in Port Valdez and through the Narrows. Thus the stopping distance used in the analysis may be conservative.

5.3.3.2.2 Causation probability of grounding in Valdez Arm

On the assumption that the causation probability P_C of grounding in Valdez Arm can be estimated from the average of the causation probabilities cited by Macduff (about 8×10^{-6} per mile of route) then the overall probability of grounding in traversing the channel area becomes

$$
\begin{aligned}
P_A &= P_B\, P_C\, S \\
&= 0.5 \times 8 \times 10^{-6}/\text{mile} \times 25 \text{ miles (approximately)} \\
&= 10^{-4} \text{ per voyage} \qquad (5\text{-}15)
\end{aligned}
$$

In analogy with the ERT treatment of the probability of rammings with icebergs, one might suspect that this result only is valid for stopping distances or turning radii which are small compared to the channel width, since these are the conditions under which Macduff's result for P_C was derived. In particular, there might be some question as to whether in Valdez Narrows with the presence of Middle Rock, the location where the restrictions on stopping distance and turning radius most clearly break down, P_C and thus P_A, would have a larger value.

This is a difficult question to address quantitatively; however, it is worth noting that the Valdez Narrows does not constitute a much narrower channel than the channels used in many other supertanker ports. The next four figures, Figures 5-6, 5-7, 5-8, and 5-9 compare the approaches to Valdez with the approaches to Europoort, Finnart, and Milford Haven, all at a scale of 1 to 50,000 (Fisken, 1977). Note that the approach to Finnart is actually narrower than the passage between Middle Rock and the opposite shore of Valdez Narrows. At Finnart, no groundings are reported since 1969, although there was one incident in which a mooring dolphin was damaged. At Milford Haven, the channel has a much sharper bend than at Valdez and has a minimum 850-foot width. There have been four or five groundings in the last three years at

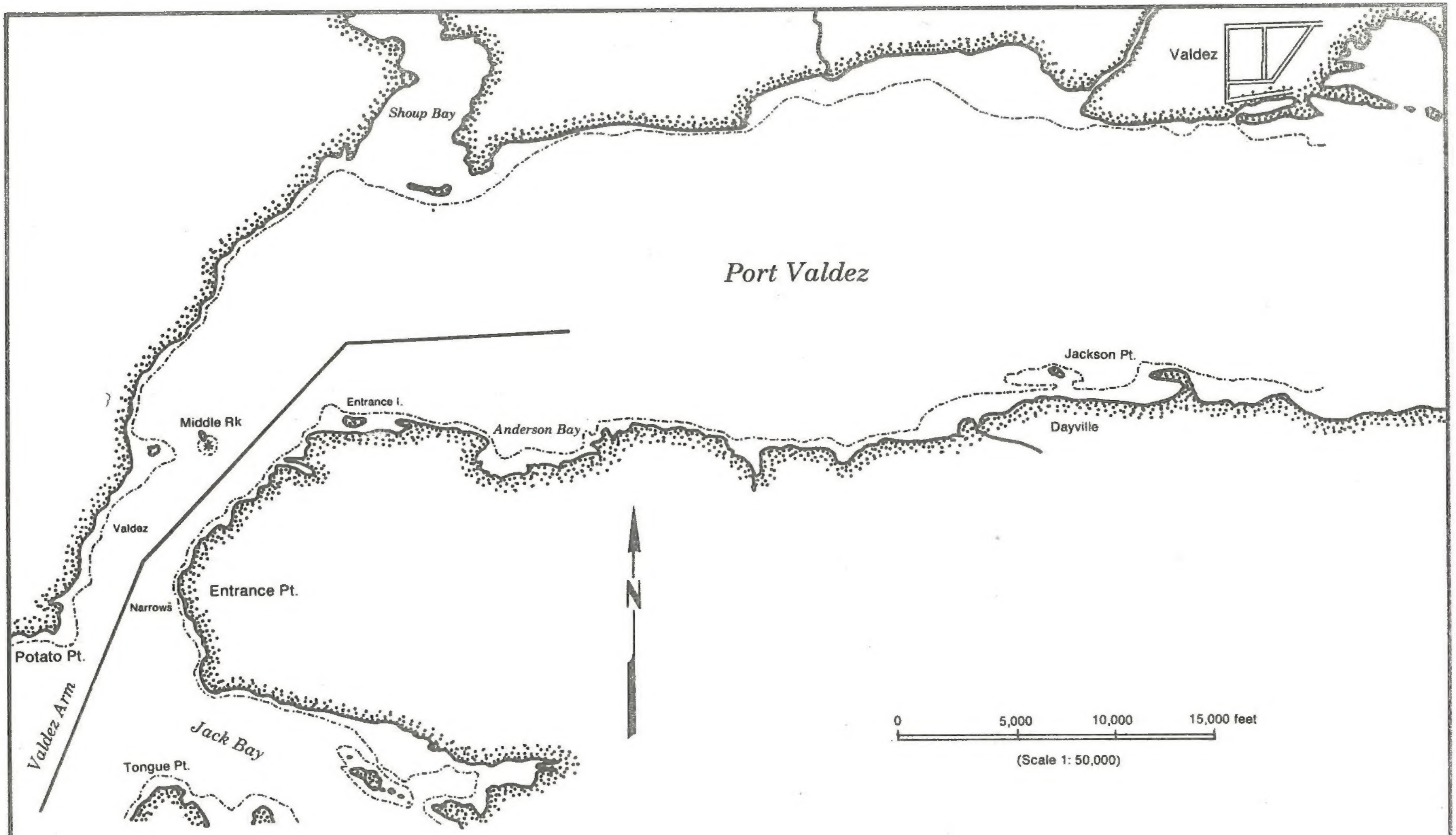


Figure 5-6 Approaches to Port Valdez, Alaska

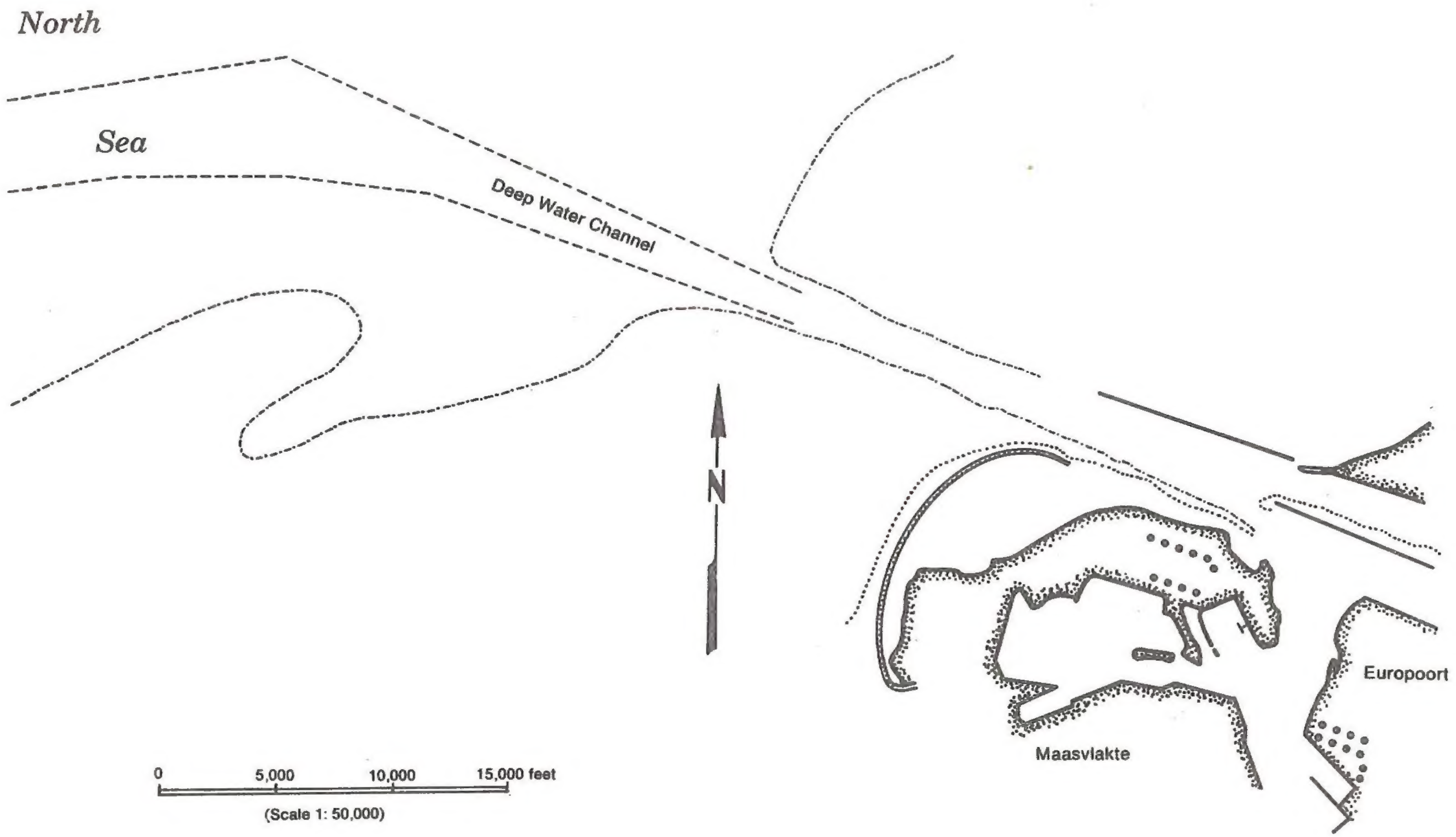


Figure 5-7 Approaches to Europoort, Rotterdam, The Netherlands

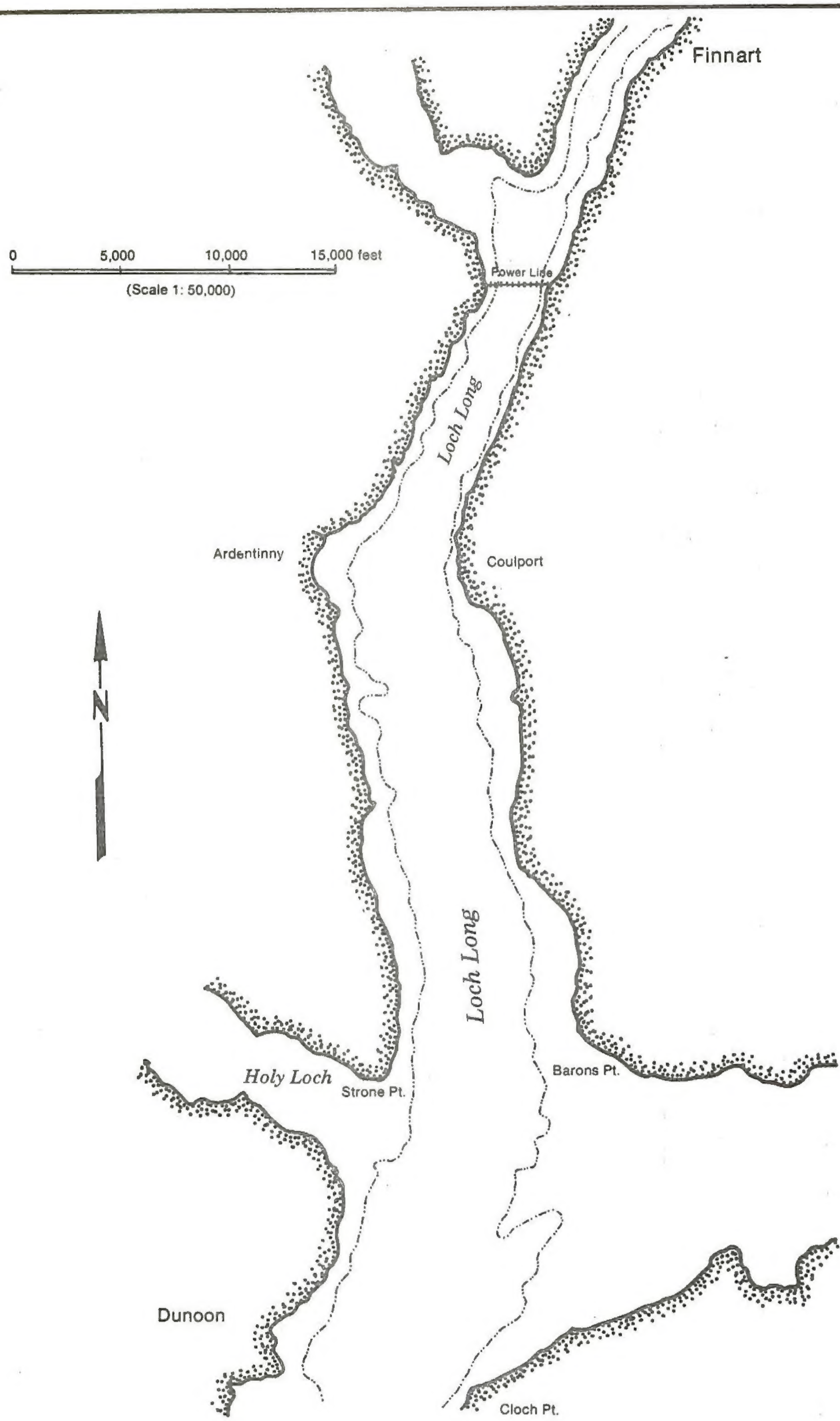


Figure 5-8 Approaches to Finnart, Scotland

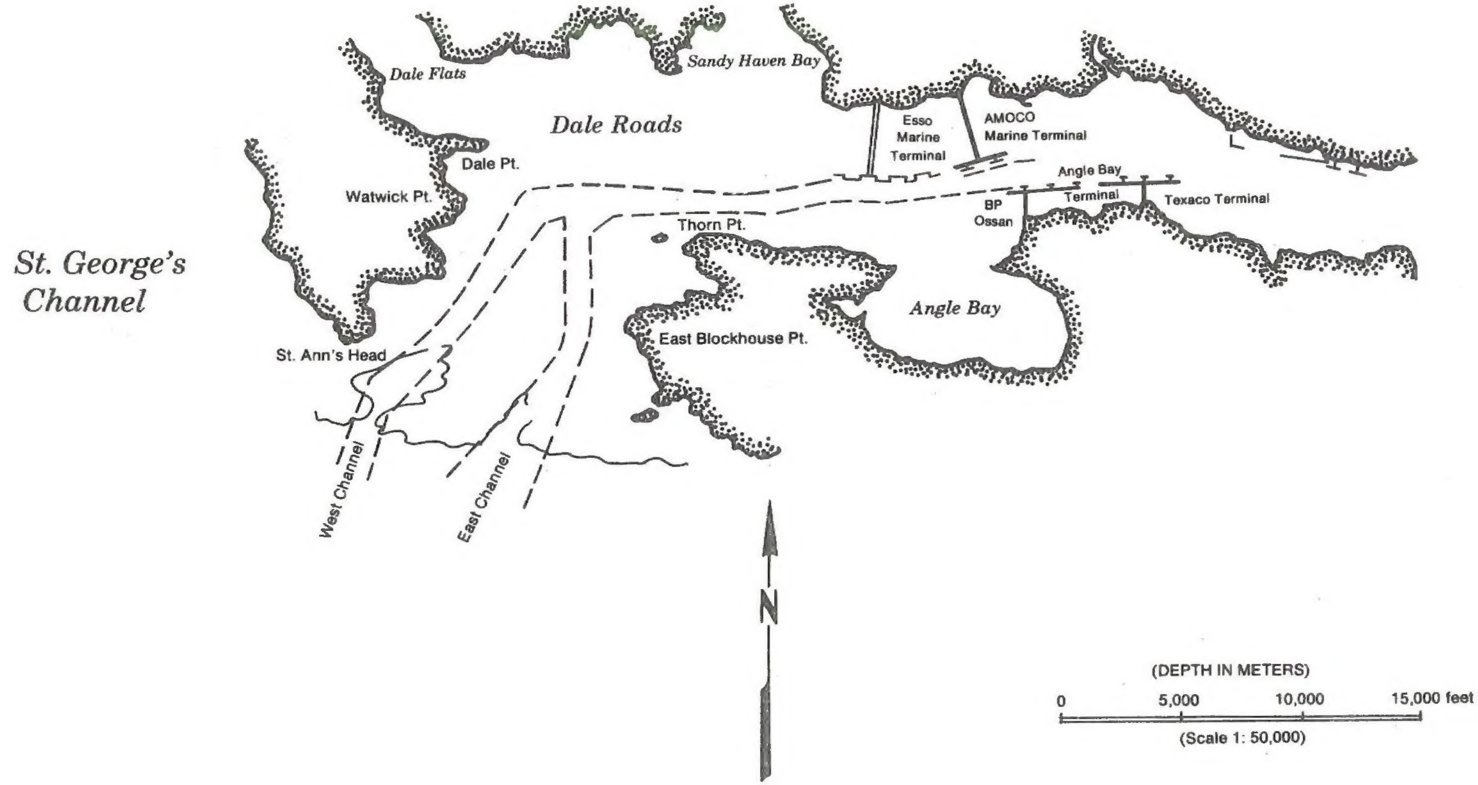


Figure 5-9 Approaches to Milford Haven, Wales

Milford Haven, only one of which caused a pollution incident. This case was from a ship which dragged anchor in a gale. One nonpolluting incident occurred by touching the edge of the channel while securing a tug, and another nonpolluting grounding incident occurred while swinging in a turning circle. There have been 12,300 tankers handled at Milford Haven in this three-year period. If one assumes five groundings and considers traffic both in and out of Milford Haven, this corresponds to a grounding probability of 2×10^{-4}, quite close to that estimated for Valdez. At Europoort (Rotterdam), where 1,900 tankers were handled in 1976, there do not appear to be any significant incidents within the last three years in spite of the fact that vessels have to maneuver within the basins of the petroleum harbors. This suggests $P_C < (3 \times 2 \times 1900)^{-1} = .9 \times 10^{-4}$, again quite consistent with the estimate for Valdez.

Based on this comparison with other supertanker ports, it would not appear that the width of Valdez Narrows and the presence of Middle Rock pose any unusual problems that would significantly increase the grounding probability estimated above. There are, however, conditions that are unique to Valdez which should be considered, in particular, the presence of unusually high winds on occasion. Table 5-11 shows results of ship simulation runs conducted at the Netherlands Ship Research Center under sponsorship of the Office of the Pipeline Coordinator, State of Alaska. These simulation runs were carried out for a variety of wind speed and gusting conditions. They also included various combinations of tugboats on a soft line and the simultaneous failure of both engine and rudder without recovery. These results are not suitable for statistical analysis for several reasons:

1. The 130 runs for which there are results constitute only part of the total set. The pilots were permitted 30 practice runs; they then did 130 runs and in 62 instances opted to take a second chance, since they felt they could do better. It was the better of

the two cases which is used in the data set presented in Table 5-10.

2. The wind speed conditions are not average conditions in any sense. They are conditions which are intentionally chosen to create a stressing situation.

3. For these runs, the ship track was chosen by the Netherlands pilots. It is not certain that the same track would be chosen by the Valdez pilots.

Nevertheless, Table 5-11 does indicate that under high wind speeds grounding situations can occur. Under the highest wind speed of 60 to 80 knots in Port Valdez, and 80 to 100 knots in Valdez Narrows, there is one instance of a grounding during simulation when one tugboat was forward and engine and rudder control were maintained. It is reasonable to assume that in this case the first chance also resulted in a grounding. With engine and rudder failure, there are several instances of grounding with wind speeds as low as 10 to 15 knots in Port Valdez and 20 to 30 knots in Valdez Narrows. Additional simulation runs are planned at the Netherlands Research Center. These additional runs will only be carried out for wind speeds below 40 knots on the presumption that vessels will not venture into Valdez Arm at higher wind speeds.

Table 5-11

Summary of Results of Tanker Simulation Runs

		Wind Speed (Knots)[a]					
		No Wind[b]	5-10	10-15	20-35	40-60	60-80
		No Wind[c]	10-15	20-30	30-45	55-75	80-100
NO TUGBOAT	Number of runs:	6	7	6	7	7	7
	Number of groundings:						1
ONE TUGBOAT FORWARD	Number of runs:			3 (3)[d]	4 (4)	11 (7)	8 (3)
	Number of groundings			1 (1)		4 (4)	4 (3)
ONE TUGBOAT AFT	Number of runs:				3 (3)	4 (4)	
	Number of groundings:				2 (2)	1 (1)	
ONE TUGBOAT FORWARD ONE TUGBOAT AFT	Number of runs:			3 (3)	5 (5)	9 (5)	8 (4)
	Number of groundings:			1 (1)	1 (1)	1 (1)	4 (4)
TWO TUGBOATS FORWARD	Number of runs:			2 (2)	4 (4)	9 (5)	7 (3)
	Number of groundings:					3 (3)	7 (3)
TWO TUGBOATS AFT	Number of runs:				5 (5)	5 (5)	
	Number of groundings:						

[a] Winds are gusting.

[b] Wind speeds in Port Valdez.

[c] Wind speeds in Valdez Narrows.

[d] Numbers in parantheses are the number of trials involving engine failure.

Assuming that traffic will be halted during high wind speeds, two questions are then of interest. First, how often may one expect wind

speeds above, say 40 knots; second, given the fact that it takes approximately two hours to traverse the route from Prince William Sound to Port Valdez, or visa versa, how far in advance may high wind speed conditions be forecast. High winds under gusting conditions do certainly occur in the Valdez area. The Environmental Sciences Services Administration, National Weather Record Center, records highest speeds for the years 1963 to 1967 as follows:

1963 -- 72 knots

1964 -- 80 knots

1965 -- several cases of 72 knots

1966 -- 100 knots (estimated)

1967 -- 62 knots

These are gusting conditions as recorded in the town of Valdez. Wind speed data has also been obtained aboard the ship Nadine in Valdez Narrows. The Nadine has recorded gusts above 30 knots on 50 days in 1975 and on 14 days in the eight-month period of record in 1976. These statistics refer to gusting rather than sustained conditions. It should also be noted that in Valdez Narrows one may anticipate that high winds would be parallel to the Channel; i.e., that the ship would be heading into or out of the wind (Selig, 1977). It is anticipated that high wind speeds for any appreciable period of time (i.e., more than gusts of a few minutes of duration), would occur during the winter when high pressures in the interior and low pressures in the Gulf cause east to north winds out of passes and river canyons (NOAA, 1975). The precision of the forecast of these severe wind conditions is such that the conditions can be forecast within 12 to 24 hours in advance of their occurrence. However, the exact beginning time for these wind conditions is subject to several variables. Therefore, only an approximate part of the day can be identified as the beginning time for these conditions. It is not only a strong surface pressure gradient that must be considered; the synoptic upper air conditions must also be

in line with or support the surface features. These conditions do not persist for very long and the probability of their persisting for much more than a day is believed to be small (Crystal, 1977).

In summary, it does not appear that Valdez Arm and Valdez Narrows present an unusual potential for grounding, provided that vessels do not venture into the channel during high wind-speed conditions. There may be some question as to the precision with which high wind-speed conditions during the winter months can be forecast. This then raises the question as to the appropriate degree of conservatism in halting tanker traffic. For example, a quite conservative approach would be to halt traffic whenever synoptic conditions conducive to high wind speeds are present. It would appear that the synoptic conditions which produce these high winds rapidly dissipate themselves, and that delays of more than a day would not be likely.

5.3.4 Site-specific effects influencing the applicability of the statistics

5.3.4.1 Introduction

This section deals in a qualitative manner with site-specific environmental and other factors which could influence the applicability of the accident statistics which are discussed in Section 5.3.2 of this study. The discussion of climatology contained herein is not intended to be comprehensive; a more detailed treatment of the synoptic climatology of the proposed Valdez-Long Beach route is presented in other referenced studies.

The environmental factors which are most likely to influence accident statistics are:

1. Incidence and extent of fog.
2. Severe storms.
3. Extreme wind and wave conditions.
4. Icebergs.

Other risk factors include:

1. Hazards due to military operations in restricted zones.
2. Collisions with OCS drilling and production platforms.

For purpose of discussion, the proposed Valdez-Long Beach tanker route may be usefully delineated in the following order:

1. Port Valdez.
2. Valdez Arm and Prince William Sound.
3. Gulf of Alaska.
4. Northeastern Pacific Ocean.
5. Santa Barbara Channel.
6. Long Beach Harbor.

In considering the incremental risks due to the factors enumerated, it is convenient to distinguish among a variety of accidents which may lead to oil spills. These include:

1. Operational accidents (rupture of loading arm, etc.).
2. Rammings, groundings, and collisions.
3. Structural or mechanical failure.
4. Fire, explosion, or breakdown.

Where appropriate, an attempt is made to identify those mitigating measures or counterposing influences which might lessen the risks.

A significant portion of the synoptic and climatological data presented in this chapter has been adapted from Volume 3 of the Final Environmental Impact Statement, Proposed Trans-Alaska Pipeline (U.S. Department of the Interior, 1972). Acknowledgment is made to Dr. Gardinere, U.S. Coast Guard, Washington, D.C.; Mr. Kellsey, Valdez Dock Co., Valdez, Alaska; Mr. L. Mayo, U.S. Geological Survey, Fairbanks, Alaska; and Dr. William O. Field, American Geographical Society, New York, who are quoted subsequently.

5.3.4.2 The general synoptic environment of the proposed Valdez-Long Beach route

The general synoptic circulation of the northeastern Pacific is controlled largely by two major semipermanent pressure centers. The Aleutian Low, the statistical mean of the procession of extratropical cyclones across the northern Pacific, is usually in existence from September to June. This trough of low pressure makes a seasonal migration between the Gulf of Alaska and the northwest Pacific. The North Pacific Subtropical High lies southeast of the Aleutian Low. This ridge of high pressure is present throughout the year; it is weakest during the winter months, but peaks as it moves northwestward in summer.

In the winter the Aleutian Low attains its maximum development and dominates the northeastern Pacific to the north of 40°N. The North Pacific Subtropical High extends in a ridge about 1,000 miles southwestward from the California coast. With the coming of spring, the Aleutian Low fills; correspondingly, the Subtropical High deepens and extends northward. By summer the Aleutian Low has disappeared and the Subtropical High extends its influence over the entire northwestern Pacific. Figures 5-10 and 5-11 display the overall relationship between these two pressure centers in January and July, respectively.

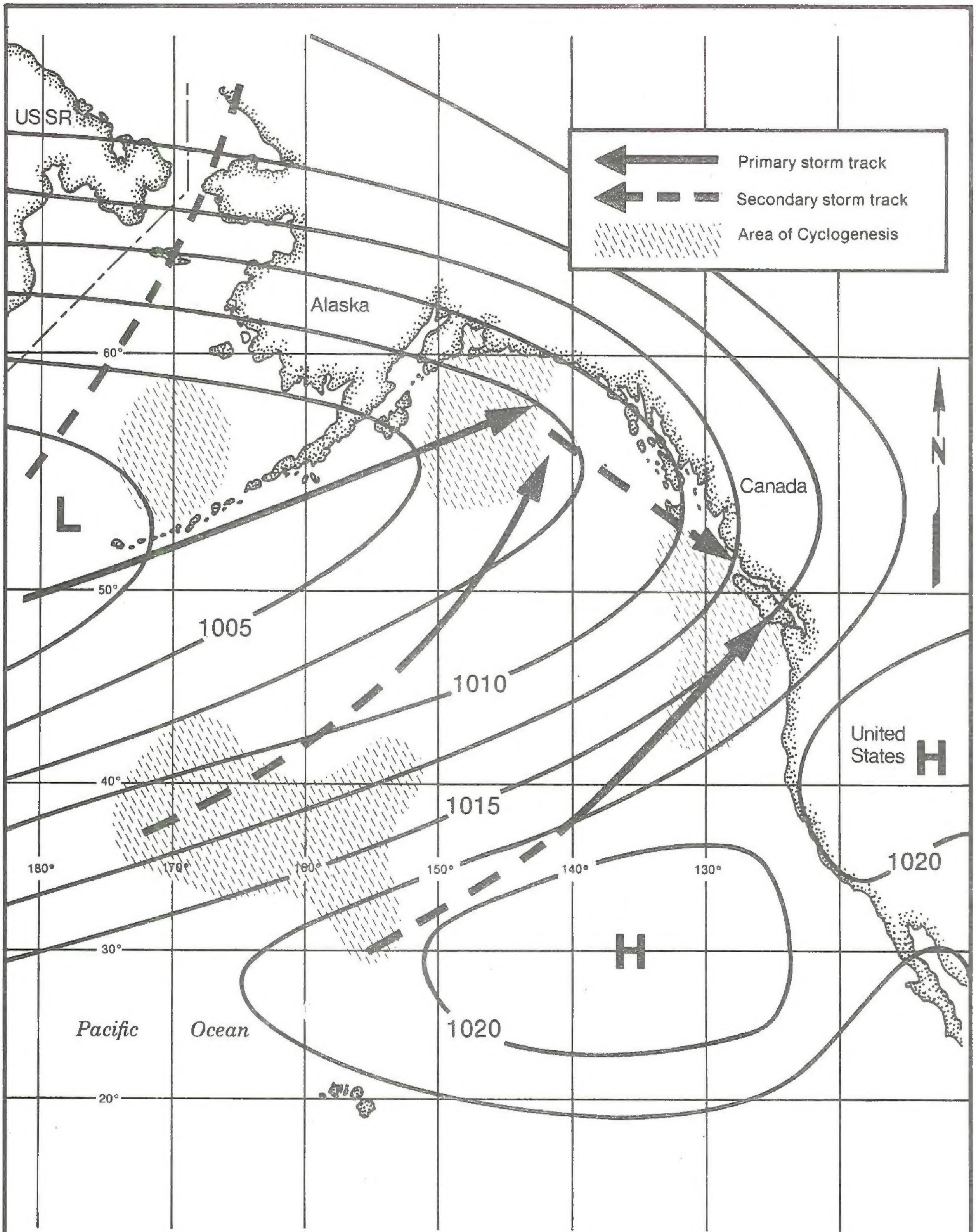


Figure 5-10 Mean monthly pressure and storm tracks, northeastern Pacific — January

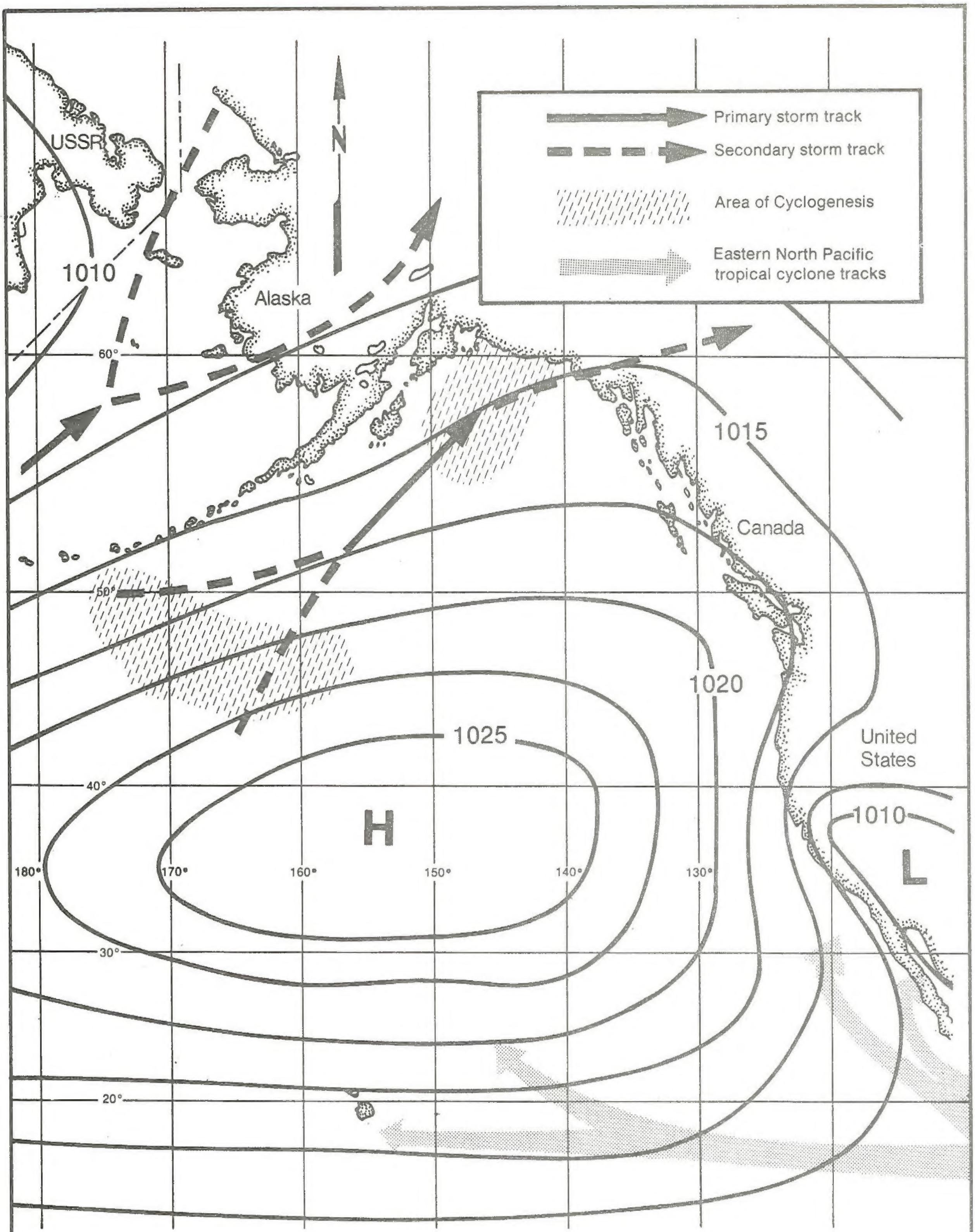


Figure 5-11. Mean monthly pressure and storm tracks, northeastern Pacific — July

With the onset of fall, the Aleutian Low gradually redevelops and the Subtropical High weakens. The center of the Aleutian Low is nearest the Gulf of Alaska in this season, bringing the lowest pressures and highest winds to the northern section in late fall and early winter.

5.3.4.2.1 Severe storms

Extratropical cyclones frequent the northeastern Pacific, particularly the Gulf of Alaska, throughout the year. Severe extratropical storms, with winds of hurricane force (≥64 kt) are encountered, principally in fall through spring. During most of this season the Gulf of Alaska has the highest frequency of extratropical cyclones in the Northern Hemisphere.

During winter months there are four characteristic areas of cyclogenesis in the northeastern Pacific. Figure 5-10 displays these areas and typical storm tracks. As shown, two primary tracks converge on the Gulf of Alaska, and another primary track approaches Vancouver Island. Note that these tracks lie astride the proposed tanker route.

In the summer (see Figure 5-11) one primary cyclone track enters the Gulf of Alaska, which remains an area of cyclogenesis. Fall conditions are essentially the same as those encountered in spring.

The tropical northeastern Pacific, which underlies the southern portion of the proposed tanker routes, is frequented by small intense hurricanes and tropical storms during the warm months (May through November). Eastern North Pacific Tropical cyclones seldom affect waters north of 30°N and therefore should not pose a serious threat to ships traversing routes between Alaska and southern California.

5.3.4.2.2 Winds

During the winter season, average wind speeds in the northeastern Pacific range from about 26 knots (in December) at Ocean Weather Station "P" (50°N, 45°W), to about 21 knots in the northwestern Gulf of Alaska. Off the Washington coast, the December mean wind speed is about 18 knots. Mean December winds in the Santa Barbara Channel range from 9 to 13 knots. By contrast, in summer, mean wind speeds are generally 10 to 15 knots over the entire northeastern Pacific area.

Gale winds (winds ≥34 kt) vary in frequency over the tanker route with season and latitude. The region south of San Francisco and east of 125°W seldom experiences a frequency of gales in excess of 2 percent. Gale frequencies are highest in the north central Pacific, diminishing slightly toward the Gulf of Alaska, and decreasing significantly with latitude. The central portion of the proposed tanker routes experiences gale winds 15 percent of the time from October through February, with a maximum of 26 percent in December. In November and December, more than 7 percent of the winds are strong gales (≥41 kt). Ocean regions adjacent to Prince William Sound experience gales 15 to 17 percent of the time in November and December.

As spring approaches, gale frequencies decrease; by April most coastal areas between San Francisco and the Gulf of Alaska experience gale frequencies of 2 to 6 percent, with the higher values recorded in the Gulf of Alaska. (Weather Station "P" displays frequency of gales of 11 percent in April.) During the summer, most of the northeastern Pacific experiences gale frequencies of 2 percent. Early fall brings a return of the transition conditions that occurred in spring.

5.3.4.2.2 Fog

In general, throughout much of the year the northeastern Pacific Ocean and Gulf of Alaska are subject to frequent occurrences of fog. These occurrences are principally, but not exclusively, advective fogs; that is, due to the advection of stable, moist air over cool offshore waters. Such fog episodes can be extremely widespread; for example, NIMBUS 3 photographs centered approximately at 50°N, 139°W, reveal to a trained photointerpreter a widespread belt of dense fog blanketing Prince William Sound and much of the eastern portion of the Gulf of Alaska. 'Contrails' are visible and have been demonstrated to be the result of ships passing through light or moderate fog (pers. comm., J. Bowley, ERT). Such contrails can be tracked for hundreds of miles and provide important evidence of the often pervasive extent of fog conditions. Other ESSA satellite photographs also show large expanses of dense fog, ranging for considerable distances seaward of the California coast, and extending from north of Eureka to south of Long Beach. Thus, both the northern and southern portions of the proposed tanker routes may be impacted by dense fog for considerable stretches.

Fog is important, of course, in that it can severely reduce visibility. Over most of the northeastern Pacific, the frequency of occurrence of restricted visibility (i.e., less than 2 nautical miles) is a maximum in the summer months. Most coastal areas north of 34°N have very limited visibility due to fog (<1/2 nautical mile) about 3 to 5 percent of the time during the summer months. South of 34°N, visibility is generally good throughout the year. The area in the vicinity of Weather Ship "P" has restricted visibility, with a frequency of 21 percent and heavy fog-limited visibility about 10 percent of the time in July.

Fall brings improved visibility to the northern waters. All areas north of 40°N have frequencies of restricted visibility of 2 to 7

percent in October. California coastal areas between 34°N and 40°N experience restricted visibility 7 and 14 percent of the time, where the upper limit results from heavy local fog in the vicinity of the Santa Barbara Channel. Near the western tip of Santa Barbara Island, restricted visibility is encountered 20 percent of the time in October.

In winter, restricted visibility occurs 3 to 6 percent of the time off California and 6 to 10 percent in most northern areas and in the open seas. In April, coastal areas show a frequency of restricted visibility of less than 5 percent (except for the Santa Barbara Channel area, which remains high). In winter, restricted visibility in northern areas results from both fog and heavy precipitation.

The frequency of restricted visibility in the Santa Barbara Channel ranges from 14.1 percent in October to 2.2 percent in January. During October, visibility is less than 2 miles more than 20 percent of the time in some parts of the Santa Barbara Channel region. In January, the figure drops to less than 2.5 percent over most of the ocean near the Santa Barbara Channel.

As suggested by the fog signal operational statistics shown in Table 5-12, there is a very appreciable annual incidence of fog along the coastal portions of the Valdez-Long Beach route, especially in the immediate vicinities of the tanker terminus points of Port Valdez and Long Beach. In particular, fogs at Point Arguello are invariably thick, and this point is recognized by mariners as one of the most dangerous on the coast.

Table 5-12

Average Number of Hours of Operation of Fog Signals

STATION	J	F	M	A	M	J	J	A	S	O	N	D	YR	MAX 1 YR
Cape Hinchinbrook	95	125	115	85	66	78	121	121	95	81	77	108	1130	2537
Point Reyes	119	119	95	87	122	136	338	380	247	232	157	140	2192	2920
Farallons	128	123	77	74	96	129	260	288	206	203	157	145	1886	2479
Point Arguello	72	77	58	79	96	135	241	233	190	175	89	82	1527	2832
Anacapa Island	70	78	56	93	80	123	153	159	124	151	103	100	1290	1883

5.3.4.2.4 Extreme winds and waves

Statistical methods developed by Thom (Thom, 1968; Thom, 1971) can be used to compute mean recurrence intervals for rare occurrences of extreme sustained winds and waves of extreme height. These methods have been applied to observations taken at Ocean Weather Station "P." The recurrence intervals and maximum values which have been derived should be reasonably representative of the extreme conditions which might be encountered over the northern half of the Valdez-Long Beach route. The results obtained for Weather Station "P" are shown in Table 5-13 (U.S. Department of Interior, 1972):

Table 5-13

Extreme Weather Conditions at Ocean Station "P"

MEAN RECURRENCE INTERVAL	2 yr	10 yr	20 yr	25 yr	50 yr	100 yr
Maximum Sustained Wind (kt)	80	99	107	109	118	128
Maximum Significant Wave Height (ft)	36	49	58	65		
Extreme Wave Height (ft)	64	89	104	118		

Corroborative evidence is provided in the extreme event of October, 1968, when the drilling rig SEDCO 135F, anchored in Queen Charlotte Sound reported a wave close to 100 feet which smashed against her supports. Significant wave height (height of the one-third highest waves) was 65 feet.

Another class of extreme wind conditions is encountered in coastal Alaskan waters. Violent downslope (katabatic) winds occur frequently on the leeward side of the coastal mountain range surrounding the Gulf of Alaska. These downslope winds, which result from coastal spillage

of cold air from intense highs over interior regions, are extremely dangerous because of the suddenness of their onset and their extreme gustiness. These winds are usually perpendicular to the coast and extend seaward as much as 30 miles from the coast.

Since local topography exects a dominant sheltering influence, the maximum wind gusts recorded at Valdez (over 100 kt) may not truly represent the gust extremes which might be encountered in Prince William Sound.

5.3.4.3 Qualitative assessment of incremental risks associated with environmental factors

5.3.4.3.1 Fog

Because fog represents so conspicuous a hazard to navigation, it is treated by mariners with great respect. Indeed, the presence of fog seems to result in greater-than-usual alertness of ship crews (pers. comm., Dr. Gardinier, USCG Hq). It is reasonable, therefore, to suppose that with adequate navigational aids and communication links, the presense of fog, per se, will not contribute materially to the probability of tanker collisions, rammings, or groundings especially in those portions of the route which are wholly under the control of the Prince William Sound VTS, or under the supervision of the contract pilot's traffic control system in Santa Barbara Channel.

The principal incremental risk of accident caused by fog arises from the possibility that, during the coastal waters or open-seas portions of the tanker routes, a smaller vessel, with inadequate or inoperable navaids/communications, might stray into the path of a tanker and would be unable to take corrective action in time. Such potential collisions should not result in massive spills, assuming that the tankers are defensively ballasted; they might, however, represent a source of small

to moderate spills. No quantitative basis exists for estimating the incremental risk of such fog-related collisions, or the associated volume spill size.

Sustained episodes of heavy fog might represent a second source of collisional accidents if vessels are forced to queue in staging areas to await better visibility conditions before entering port. It is even conceivable that tanker port traffic might be halted entirely at times. Interestingly, however, long-term experience at Valdez does not appear to support this conjecture. We understand from Mr. Kellsey, who has long been associated with the Valdez Dock Company, that, to his knowledge, no vessel has ever been prevented from proceeding into Port Valdez because of fog; fog is not, he asserts, an operational problem at Valdez. It is not known at present whether experience at the Port of Long Beach is similar to that at Valdez. It should be noted that during episodes of fog it is mandatory that speed be reduced to the point that a vessel can stop completely within its visual range. Prolonged periods of fog may, therefore, play havoc with the economics and logistics of the entire tanker transport system for Alaskan crudes. There may be strong motivation for a ship's master to proceed through fog; such pressures might well work to increase the risk of collisions or groundings. Again, there is no basis for assigning a quantitative estimate of incremental risk due to such events.

Mitigating measures which will tend to reduce the incidence of fog-related accidents, or lessen their severity, include:

1. Mandatory Vessel Traffic System control or its equivalent.

2. Mandatory use of designated traffic lanes.

3. Adequate navigational aids, including radio, and direction-finding systems such as LORAN.

4. Upgrading or establishment of warning devices (lights, bells, etc.) to identify fixed obstacles or hazards.

5. Reliable ship-to-shore and ship-to-ship communication links to facilitate rapid exhange of warnings or advisories.

6. Design features such as double hulls, defensive placement of ballast, segregated ballast compartments, lateral bow thrusters, etc.

5.3.4.3.2 Severe storms

As previously discussed, severe storms frequently migrate through the proposed tanker traffic route. Accordingly, the tankers designated for service on the Valdez-Long Beach route must be able to withstand severe wind and wave conditions. A fully loaded modern 150,000 DWT tanker rides very low in the water, presenting little freeboard. Even winds as severe as 100 knots, and concomitant high waves, should be readily accommodated by such a tanker, assuming that it retains propulsive power to permit heading into the wind (pers. comm., Dr. Gardinier, USCG). In open waters, the principal incremental risk due to severe storms is probably associated with loss of propulsion. In such an event, there is danger that repeated broadside buffeting may induce or hasten a structural failure or mechanical breakdown. No data base is known from which quantitative inferences can be drawn about the ability of a modern Valdez-Long Beach tanker to withstand severe storm pounding if dead in the water; nor is there sufficient data to estimate the significance of other breakdowns, such as loss of rudder control. Therefore, no estimate of the incremental risk of a major spill associated with a relatively high frequency of severe storm systems in the proposed shipping lanes is possible.

Of more direct concern, however, is the augmented risk of small to moderate spills associated with failure of mooring while berthed, resulting in ramming of piers or loading platforms, damage to operational loading equipment, etc. Measures to mitigate the risk of storm-induced spills while in port include:

1. Placement of breakwaters to protect loading berths.

2. Breasting and mooring dolphins.

3. Defensive tanker design (as above).

4. Rapid automatic shutoff devices to limit spills from ruptured connections, etc.

5.3.4.3.3 <u>Extreme winds and waves</u>

No statistical data were identified from which to assess quantitatively the accident risk to large modern tankers associated with rare occurrences of extreme sustained winds or waves of unusual height in the Valdez-Long Beach sea corridor. Mitigating measures, in addition to those previously identified, would focus on basic structural design, and in periodic inspection of vessels to detect and remedy the development of stress cracks and accumulated metal fatigue.

5.3.4.3.4 <u>Icebergs</u>

There is considerable controversy, at present, as to the risk of tanker collision with icebergs in the Valdez area. It is generally acknowledged that, previous to 1975, icebergs have not represented a significant risk to shipping into Valdez. There has never been, to date, an unambiguously documented case of iceberg collision in the Valdez area, although the Coast Guard has reported one suspect incident

in which a fishing vessel was lost; additionally, Dr. Field states that about 20 years ago, the mail boat into Cordoba was reported to have hit an iceberg at night in Prince William Sound. Nevertheless, in 1975, large icebergs were observed and photographed in Valdez Arm (pers. comm., L. Mayo, USGS, Fairbanks, Alaska) astride the shipping channels. These photographs (specifically those taken on 8 October 1975) are in the possession of A. Post, USGS, Tacoma, Washington, who together with L. Mayo, has been monitoring the Columbia Glacier by both aerial photographic survey and on-site measurements. The iceberg season in 1975 extended from September to November. Icebergs of estimated size 50 feet x 30 feet x 8 feet were observed in Valdez Arm, and as far south as Goose Island. Observations by Mayo and Post in 1976 appear to confirm that the Columbia Glacier is entering upon an unstable phase, which is significantly different from its past history. The observations of Mayo and Post are supported by information provided by the captains of the vessels GLACIER QUEEN, COLUMBIA QUEEN and BARTLETT, which have also reported large icebergs.

Large icebergs which are detectable by radar are no hazard to smaller vessels even in fog. During fog episodes, vessels proceed at speeds less than 4 knots, and smaller vessels (less than 100 feet in length) can readily maneuver sufficiently to avoid icebergs within visual range. Large tankers, however, are very much less maneuverable at such low speeds, especially if they are not equipped with lateral bow thrusters. Furthermore, aerial photographs indicate that typical currents at Valdez are of the order 3 to 7 knots (pers. comm., L. Mayo); a tanker proceeding at 4 knots or less may not be able to avoid collision in any case. The availability of accurate information about currents will be crucial to reducing the risk of tanker/iceberg collision.

The risk of collision is exacerbated by observations which suggest that some of the icebergs, perhaps as many as 1 percent, calved by the

Columbia Glacier carry a heavy burden of rock (moraine). Such icebergs ride very low in the water, with their tops awash. Seas higher than 2 feet will obliterate them from detection visually or by radar; even in calm seas, poor visibility may easily cause them to be missed.

More serious yet is the suggestion, advanced by Mayo, Post, and others, that the frequency of iceberg calving may be considerably greater in the near future than observed at present. An order of magnitude estimate of total ice volume calved yearly from the Columbia Glacier at present is 2-3 $\times 10^8$ m^3. This volume of calved ice corresponds to the presently stable glacier; if indeed the glacier is entering an unstable phase, the amount calved yearly might increase tenfold or more. Accordingly, it is felt by some that there is a very real risk of a tanker-iceberg collision in the Valdez area during the lifetime of the proposed project. Although it is not possible at present to quantify this risk, it is a factor which should be kept clearly in mind, particularly if the recent observations which suggest growing instability of the Columbia Glacier are substantially confirmed in the near future.

5.3.4.3.5 Military operations in coastal waters

Significant portions of the proposed coastal tanker route between Point Arena, California, and Long Beach, California, lie within the jurisdiction of one or more hazardous military operating areas. Information at present is available on a number of such operating areas which directly conflict with the proposed tanker operations. These include the following and are discussed below:

1. Areas under Twelfth Naval District (COMTWELVE) authority.

2. Areas under Pacific Missile Test Center (PACMISTESTCEN) authority.

3. Areas under Fleet Area Control and Surveillance Facility (FACSFAC) authority.

COMTWELVE conducts a variety of hazardous activities over much of the California coastal waters between Point Arena and Point Arguello. Warning Areas W-260 and W-283 are subject to bombing, rocket, aerial gunnery, aerial intercept, and other activities. Prior to actual expenditure of ordnance in any of these areas, Notice to Airmen or Mariners (NOTAM) is issued.

The proposed tanker coastal route, approximately between Point Piedras Blanco and Long Beach, crosses the PACMISTESTCEN's Sea Test Range, an area routinely scheduled for tactical operations (air-to-air, surface-to-air, air-to-surface, and strategic missile launches). Specifically, the proposed route appears to transect restricted areas W-532, C-1176/W-537, and W-289 (letter of communication and map, from Commander, PACMISTESTCEN, to BLM, SOHIO ES project, dated 5 August 1976). As stated in this letter, "The Test Center issues HYDROPACS via the Oceanographic of the Navy daily for areas in which hazardous operations are scheduled . . . local broadcasts, providing notice of hazardous operations at PACMISTESTCEN are repeated throughout normal working days and on other days when such operations are scheduled . . . . It is essential that all vessels contact "PIEAD CONTROL" on voice radio 2182 KHz, 5080 KHz, or 156.8 MHz prior to entering (these) areas . . . and that they respond to requests to hold position or alter course, during transit . . . ."

A portion of the San Pedro Channel, just south of the entrance to Long Beach Harbor, falls within the Long Beach Electronic Test Area (LBETZ). This area is used for torpedo firing, mining and mine sweeping exercises, and other hazardous activities. It comes under the scheduling jurisdiction of the Navy's FACSFAC, San Diego. There is presently in effect an agreement between Standard Oil Company of

California (SOCAL) and FACSFAC to coordinate vessel movement related to SOCAL's offshore drilling activities within the Test Area with ongoing FACSFAC operations. Similar agreement between SOHIO and FACSFAC would minimize the risk of accident due to hazardous naval operations in the Long Beach area.

It is impossible, at present, to make a quantitative estimate of incremental risks to tankers approaching Long Beach due to COMTWELVE, PACMISTESTCEN and FACSFAC operations. Obviously, extreme caution, reliable, rapid communications links, and diligent attention to warnings and directions, would be required to avoid serious accidents.

5.3.5 Delays and disruptions related to icebergs in Valdez Arm

Figure 5-4 shows distances at which icebergs were observed drifting from Columbia Glacier in relationship to the Valdez Arm during the period 8 June to 5 September 1976. There is one period of four continuous days with iceberg observations in the Arm and three periods with three continuous days of iceberg observations as shown by the asterisks in the figure. These numbers are significant because the storage tanks at Port Valdez hold seven days pipeline flow of oil. Furthermore, these storage tanks at any given time may already hold several days supply.

If we assume that the risk of oil spills resulting from tanker collisions with icebergs is controlled by delaying transit through the Arm until the shipping channels are iceberg-free, then the present storage capacity would appear marginal. In the absence of additional oil tanks, the operational choice would be either to shut down oil flow in the pipeline or to continue tanker traffic in the presence of icebergs. The pipeline is insulated to withstand 20 days delay at -20°F so this may be a valid option (pers. comm., L. Cancelmi, Aleyeska). Nevertheless, the size of the present storage capacity must

be viewed as providing some motivation for tankers to proceed through Valdez Arm while there are icebergs present.

The above discussion is, of course, predicated on the assumption that the frequency and number of icebergs in Valdez Arm over the project lifetime will remain constant. As noted, however, the iceberg risk may prove to be significantly greater during future decades than that reflected in the historic record. Surveys in 1974 and 1976 have documented a thinning and decreasing stability of Columbia Glacier. Iceberg risk in Valdez Arm (and possibly in Prince William Sound) will substantially increase in the future if this trend continues (Mayo, 1977). If the number and frequency of icebergs were to increase greatly, then additional storage capacity might not be an economically feasible alternative. The remaining alternatives for controlling risk from tanker traffic must involve outfitting the tankers so as to avoid damaging collisions.

If the realities of pipeline operation make disruption or delay of tanker traffic during the iceberg season unacceptable (or unlikely), then measures should be considered which will reduce the hazard to ships traversing Valdez Arm in the presence of icebergs. Risk reducing measures can be divided into two categories: (1) measures that reduce the risk that a tanker will hit an iceberg, and (2) measures that reduce the risk of substantial damage to the tanker if it collides with an iceberg. Reducing ship speed is one fairly obvious precaution that reduces the risk of collision and the risk of damage in the event of a collision. However, there are insufficient data on iceberg collisions with tankers to determine if it is feasible to traverse iceberg fields by proceeding slowly and maneuvering between icebergs or simply pushing the icebergs out of the way. If speed reduction does prove to be a practical measure and is widely used, detection of icebergs will be crucial. Some growlers may be so dense and laden with rock that they are too low in the water to be detected visually or by radar.

Detection of these small, dense growlers may be possible with sonar. One study on an iceberg avoidance sonar system for supertankers indicates that such systems are feasible and could detect growlers presenting a cross-sectional area of 40 square feet at a range of 5,000 yards (about 2.8 miles) (Lee, et al., 1976). The installed cost of a sonar system with the required capabilities is on the order of $1 million to $2 million per tanker (Lee, et al. 1976).

Complete avoidance of collisions with icebergs cannot be assured when the number of icebergs in the channel gets large, even with complete detection of icebergs. As indicated previously, instances of more than 100 icebergs in Valdez Arm have occurred. Tanker traffic during these periods can be safely continued only if the ships can withstand collisions with some icebergs. There are insufficient data at this time concerning collisions of tankers and icebergs to determine what size iceberg can be hit or what the maximum ship speed can be at the time of collision to preclude significant tanker damage or oil spillage. Available information does indicate that significant damage can be done by growlers being hit at relatively low speed by ships which are not designed for striking ice. If TAPS tankers are to safely traverse dense iceberg fields, they will probably have to be retrofitted with bows designed for striking ice. Two approaches to bow design could be taken. One approach is to strengthen the bow to rigidly resist collision with small icebergs. The other approach is to make the bow section of the ship crushable, thus absorbing the energy of impact without severely disabling the ship. Obviously, any retrofit of bow design on TAPS tankers will be expensive in absolute terms, several million dollars per tanker (Jones, 1977). However, in relation to the cost of the total loss of a tanker or to the cost of a large oil spill, the cost of structural changes may be reasonable.

Other mitigating measures to reduce the numbers of icebergs or the larger icebergs may be possible. The towing of icebergs out of the

shipping lanes or the "fencing off" of Columbia Bay to prevent icebergs from entering Valdez Arm are examples of actions which may reduce collision probabilities.

5.3.6 Results of the analysis

The results contained in this section indicate that the statistics for a spill of any size are dominated by the more numerous spills where the vessel is not a total loss. The total volume spilled, however, is determined by the probability that a vessel will be a total loss.

The probability of a loaded vessel being totally lost from any cause in any location is found from Equation (5-1) to be 2.25×10^{-2} per year. This is a probability of 0.56 over a 25-year project life. The volume of this spill could be from 0.6 to 1.2 million barrels depending on the vessel involved. Loss of a vessel in coastal waters would result in more severe impacts than from a loss in the open ocean. Using equation (5-1) the probability becomes 0.012 over a 25-year project life, or one total loss in coastal waters every 85 years. It is important to realize that even for a total vessel loss, some oil could be salvaged. Furthermore, during foundering and sinking, oil loss from the ship to the ocean might be spread over a considerable period of time. In spite of these caveats, for simplicity in the analysis which follows, it is assumed that total loss of a loaded vessel implies a spill of the entire load. If the total vessel loss case is excluded, then Equation (5-3) gives a spill probability from any cause in any location of 0.35 per year, with a volume of 1,260 barrels calculated from Equation (5-4).

Table 5-14 shows how the probability of total loss is distributed by expected spill volume and location. In deriving Table 5-14, the report by Socio-Economic Systems (SES, 1976) was followed in assigning three-quarters of the pier, harbor, and entrance spills to calls at Valdez

and one-quarter to Long Beach. It must be admitted, however, that other than the qualitative aspects of fog, storm, and icebergs in Valdez which are discussed in this report, there is little data on which to base such a split. The only tanker casualties listed by the U.S. Coast Guard since 1969 for Prince William Sound are two minor groundings. During this period, there were 339 tanker visits to Valdez (Federal Power Commission, 1976). In the Port of Long Beach, there have been no collisions, rammings, or groundings in the past 10 years (SES, 1976).

The coastal locations of spills within the 350-mile long portion of the tanker route from San Francisco to Long Beach, where the designated sea lanes are within 50 miles of shore, are also identified. The "at sea" location in previous tables is then identified with the Prince William Sound to San Francisco portion of the route in Table 5-14.

According to Table 5-15, total loss of a 120,000 DWT vessel carrying 0.84×10^6 barrels is slightly more likely than total loss of an 80,000 DWT vessel carrying 0.57×10^6 barrels of oil. Both events are about 30 percent more likely than total loss of a 165,000 DWT vessel carrying 1.19×10^6 barrels of oil. In part, these differences arise from different vessel characteristics, as discussed below. In part, they also arise from differing numbers of trips by weight class.

Table 5-16 presents a similar analysis for less than total losses. For these events, probability of a spill is greatest at sea or in Prince William Sound as is the probable annual volume spilled. Volumes have been calculated using Equation (5-4).

Table 5-17 combines results from Tables 5-15 and 5-16. The significant feature is that the addition of total vessel losses to other spills hardly changes the probabilities, but increases the average volumes spilled by at least an order of magnitude. The volumes given in Table

Table 5-14

Probability per Year of Total Vessel Loss, Loaded Condition Only

MAXIMUM SPILL VOLUME	Prince William Sound (Valdez)	Prince William Sound-San Francisco	San Francisco-San Pedro Bay	San Pedro Bay (Long Beach)	Total
0.57×10^{6}	2.52×10^{-3}	3.07×10^{-3}	1.61×10^{-3}	0.84×10^{-3}	8.04×10^{-3}
0.84×10^{6}	2.84×10^{-3}	3.22×10^{-3}	1.30×10^{-3}	0.95×10^{-3}	8.31×10^{-3}
1.19×10^{6}	2.12×10^{-3}	2.05×10^{-3}	1.32×10^{-3}	0.71×10^{-3}	6.20×10^{-3}
Total	7.48×10^{-3}	8.34×10^{-3}	4.23×10^{-3}	2.50×10^{-3}	2.25×10^{-2}

Table 5-15

Probability of a Spill per Trip P_T for Each Vessel Type

PARAMETER	Vessel Type	P_T	P_T/bbl Capacity
N=1	SOHIO-owned 165 x 10^3 DWT, inerting system, defensive ballast	5.96×10^{-4}	5.00×10^{-10}
N=2	SOHIO-owned 120 x 10^3 DWT, inerting system, defensive ballast, double hull	3.92×10^{-4}	4.67×10^{-10}
N=3	SOHIO-owned 80 x 10^3 DWT	7.24×10^{-4}	12.7×10^{-10}
N=4	Not SOHIO owned 120 x 10^3 DWT, defensive ballast, double hull	3.94×10^{-4}	4.69×10^{-10}

TABLE 5-16

Probability per Year of Spills with Less Than Total Vessel Loss with Average Spill Volumes[a]

Prince William Sound (Valdez)		Prince William Sound-San Francisco		San Francisco-San Pedro Bay		San Pedro Bay (Long Beach)		Total	
Probability	Volume	Probability	Volume	Probability	Volume	Probability	Volume	Probability	Volume
0.11	389	0.13	439	0.077	302	0.037	130	0.35	1,260

[a] In barrels.

TABLE 5-17

Probability per Year of Spill for All Casualties with Average Spill Volume[a]

Prince William Sound (Valdez)		Prince William Sound-San Francisco		San Francisco-San Pedro Bay		San Pedro Bay (Long Beach)		Total	
Probability	Volume	Probability	Volume	Probability	Volume	Probability	Volume	Probability	Volume
0.12	6,730	0.14	7,333	0.086	3,883	0.040	2,243	0.39	20,189

[a] In barrels.

5-17 are due almost entirely to a total loss which, as noted earlier, has a probability of 0.56 of occurring over a 25-year project life.

Some further appreciation of the likelihood of a total vessel loss can be obtained by assuming that such rare events obey Poisson statistics with the most probable value 0.56. Table 5-18 then gives the likelihood of more than one-total-vessel losses during a 25-year period from the formula

$$P(k) = \frac{\exp(-0.56)(0.56)^k}{k!} \qquad (5\text{-}15)$$

Table 5-18

Probability of k Total Vessel Losses
Over a 25-Year Project Life

k	P(k)
2	8.9×10^{-2}
3	1.6×10^{-2}
4	2.3×10^{-3}
5	2.6×10^{-4}

It is of interest to know the dominant factors which produce the spill probabilities and volumes in Tables 5-15 and 5-16 in the event that mitigating measures are considered. Table 5-15 shows the relative importance of one set of such factors: namely, different vessel characteristics. This table gives the probability of spill per trip $P_T = \sum_{ij} P_{ij} Q_{ij}$ for each vessel type. Table 5-15 indicates that the addition of an inerting system, defensive ballast, and a double hull lowers the spill probability per trip by a factor of $\frac{3.92}{7.24} = 0.54$.

Table 5-19

Yearly Probability of a Spill by Casualty Type, Entire Fleet

CASUALTY	Total Loss	Less Than Total Loss
Collision, Ramming, Grounding	4.9×10^{-3}	8.1×10^{-2}
Fire, Explosion, Breakdown	9.3×10^{-3}	2.9×10^{-2}
Structural Failure	8.4×10^{-3}	3.0×10^{-2}

Table 5-15 also gives P /barrel capacity which is the spill probability per trip per barrel carried. Clearly all components of the fleet are competitive except the 80,000 DWT tankers which have about 2.5 times greater spill probability for the same amount of oil delivered. Spill probability is not the only parameter of interest: The potential amount of the spill must also be considered in evaluating ecological effects.

Table 5-19 shows the relative importance of a different set of factors, namely casualty type. Results are given for the entire fleet for both total losses and less than total losses. According to this table, collisions, rammings, and groundings are the most probable causes of spills when the vessel is not a total loss. For total losses, however, fires, explosion, and breakdown or structural failure are more likely. Perhaps the most interesting aspect of these results is that the three major categories of casualty type are all competitive to within a factor of three. This means that an overestimate of the spill probability for any one casualty type will not produce a major overestimate in the aggregate spill probability.

There must be a generic bias affecting all casualty types to result in highly overestimated final results. In fact, there may be such a generic bias although it probably is not large. This bias may arise

from using world tanker fleet data rather than U.S. fleet data in the analysis. Data for <u>all ships</u> for the period 1969-1974 indicate that the U.S. fleet lost ships at a rate 29 percent below the world fleet and gross tonnage at a rate 38 percent below the world fleet (SES, 1976).

In conclusion, results of this section are compared to those of SES (1976). Comparison is made of Table 5-17 and SES results for <u>accidental spills only</u> on a yearly basis (from Tables 26 and 27 of that report). The comparison is shown in Table 5-20. It should be noted that in addition to somewhat different fleet composition assumptions, two quite different methodologies have been used. ERT has treated total losses as a distinct category and has found that these events dominate the yearly volumes spilled. Socio-Economic Systems assumed an average "large spill" of 2 million gallons (about 48,000 barrels) based on the data of Devanney and Stewart (1974) and multiplied by the expected number of spills.

<u>Table 5-20</u>

Comparison of Present Results With Those of Socio-Economic Systems for Yearly Accidental Spill Volumes

	Prince William Sound	At Sea	Coastal	Long Beach	Total
Present results	6,730	7,333	3,883	2,243	20,189
Socio-Economic Systems	5,856	9,760	2,928	1,563	20,107

SUBAPPENDIX A

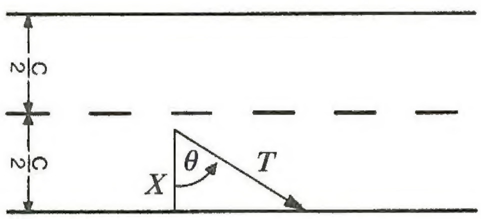
GROUNDING PROBABILITY FOR A BLIND RANDOMLY NAVIGATED VESSEL IN A CHANNEL OF CONSTANT WIDTH (BUFFON'S NEEDLE PROBLEM)

Consider a vessel which may be characterized by a stopping distance T proceeding along a channel of width C at an angle $\frac{\pi}{2} - \theta$ from the channel centerline and a distance X from the nearer channel edge, as shown in the diagram below. Because of symmetry it is necessary only to treat the half channel for the moment; i.e., $0 \leq X \leq C/2$. For $T \leq C-X$ angles from 0 to $\cos^{-1}(X/T)$ will lead to a grounding. For $T \geq C-X$ angles from $\pi - \cos^{-1}(C-X)/T$ to π also contribute. These angular intervals thus constitute a fraction

$$\frac{1}{\pi}\cos^{-1}\frac{X}{T}, \text{ for } T \leq C - X, \text{ or}$$

$$\frac{1}{\pi}\left(\cos^{-1}\frac{X}{T} + \pi - \cos^{-1}\frac{C-X}{T}\right)$$

for $T \geq C-X$ of the total range of possible angles in the direction the vessel is assumed to be proceeding.



Geometry for the Buffon's needle problem

Noting that the differential value dx constitutes a fraction dx/(C/2) of the allowed values of X and introducing a factor of 2 for the other side of the channel it is found that:

$$P_B = 2\left\{\int_{o}^{\text{smaller of } T, \frac{C}{2}} \frac{1}{\pi} \cos^{-1} \frac{X}{T} \frac{dx}{(C/2)}\right\} \tag{A-1}$$

$$+2\left\{\int_{\text{lower of } o,\, C-T}^{C/2} \frac{1}{\pi} \left[\pi - \cos^{-1} \frac{(C-X)}{T}\right] \frac{dx}{c/2}\right\} \text{when } T > C/2$$

$$= \frac{4}{\pi C} \left\{\left[X \cos^{-1}\frac{X}{T} - \sqrt{T^2-X^2} \,\right|\, \right]_{o}^{\text{smaller of } T, \frac{C}{2}}\right\}$$

$$+ \frac{4}{\pi C}\left\{\left[\pi X + (C-X) \cos^{-1} \frac{C-K}{T} - \sqrt{T^2 - (C-X)^2}\,\right|\right]_{\text{larger of } o,\, C-T}^{\frac{C}{2}}\right\} \text{ when } T>C/2$$

The limits T and C-T occur in Equation (A-1) because the stopping distance T must be large enough for grounding to occur on the channel edge in question. From Equation (A-1) we have:

$$P_B = \frac{4T}{\pi C} \text{ when } T \leq C/2 \tag{A-2}$$

$$P_B = \frac{4T}{\pi C} \left[1 + \pi \left(1 - \frac{C}{2T}\right) + \frac{C}{T} \cos^{-1} \frac{C}{2T} - 2 \left(1 - \frac{C^2}{4T^2}\right)^{1/2}\right]$$

$$\text{when} \quad C/2 \leq T \leq C$$

$$P_B = \frac{4T}{\pi C} \left[1 + \pi\frac{C}{2T} + \frac{C}{T} \cos^{-1} \frac{C}{2T} -2 \left(1 - \frac{C^2}{4T^2}\right)^{1/2}\right.$$

$$\left. - \frac{C}{T} \cos^{-1} \frac{C}{T} + \left(1 - \frac{C^2}{T^2}\right)^{1/2}\right]$$

$$\text{when} \quad C \leq T$$

P_B is a continuous function of T/C and has the value unity for $T/C = \infty$.

SUBAPPENDIX B

SHIP COLLISION MODEL (AFTER REFERENCE 2)

The geometry for the ship collision model is shown in Figure B-1. The various symbols are defined as follows:

V_t , V_i = tanker and ship speeds

ℓ_t, ℓ_i = tanker and ship lengths

b_t , b_i = tanker and ship beams

θ = crossing angle of the tanker with the ship stream

η = density of ships; i.e., number of ships per unit area

Z = width of ship stream

θ_r = relative tanker incoming angle to a ship

V_r = relative speed of the tanker to a ship.

In a reference frame in which the ship stream is stationary, the number of collisions is $\eta_o \sigma_c Y$, where Y is the distance traveled by the tanker in this frame and σ_c is the collision cross section for an individual encounter in this frame. η_o is the density of ships for which a collision would be of the type of interest (crossing, head-on, overtaking). The actual collision probability per unit distance is thus

$$P_B = \eta_o \sigma_c \frac{Y}{S} \qquad \text{(B-1)}$$

In this frame of reference the velocity V and angle are found from Figure B-1 to be:

$$V_r = (V_i^2 + V_t^2 - 2V_iV_t \cos \theta)^{1/2} \qquad \text{(B-2)}$$

and

$$\theta_r = \cos^{-1} \{(V_i - V_t \cos \theta) / (V_i^2 + V_t^2 - 2V_iV_t \cos \theta)^{1/2}\} \qquad \text{(B-3)}$$

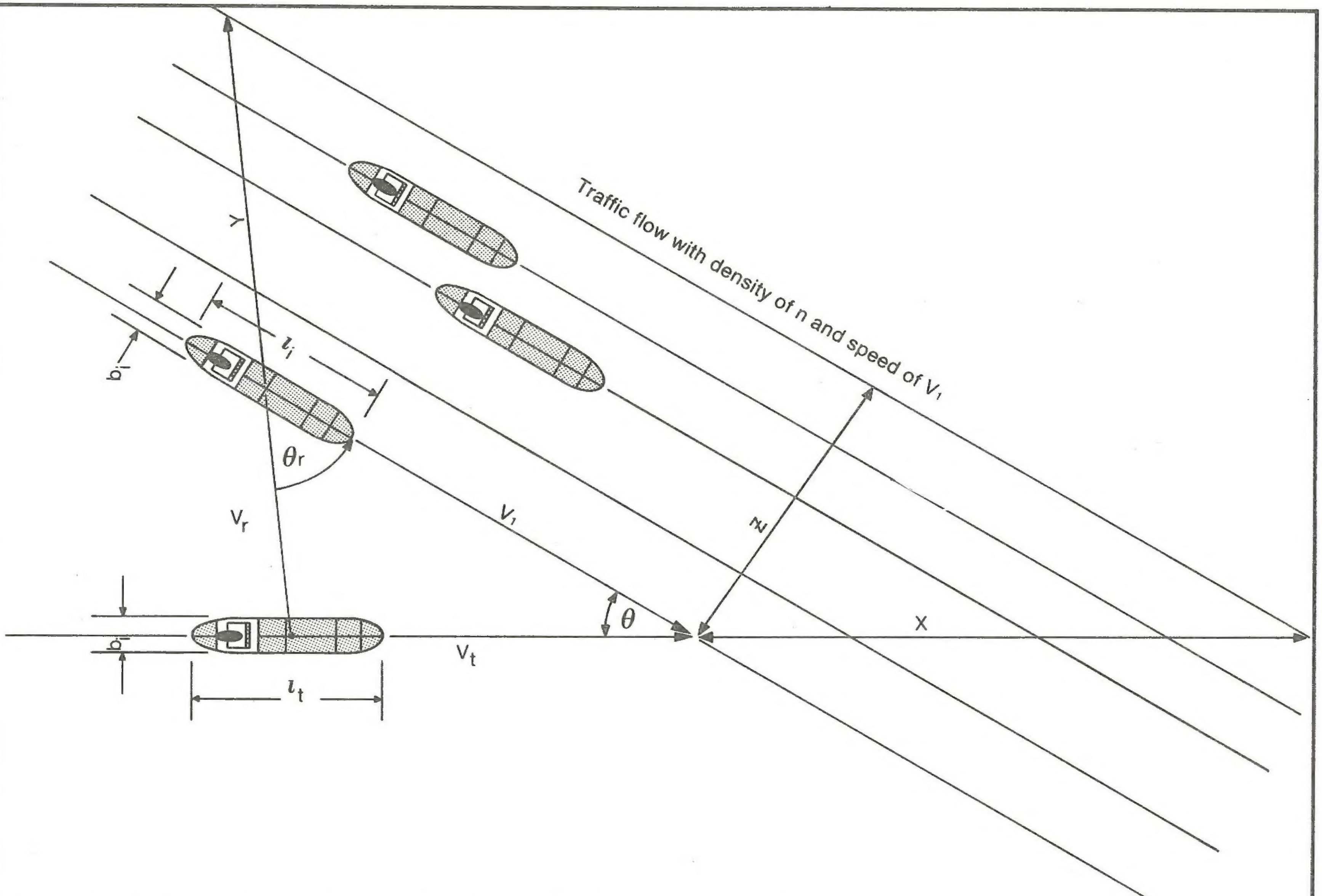


Figure B-1 Basis for calculation of ship collision model

and the collision cross section, also determined from Figure B-1 is

$$\sigma_c = \begin{cases} (\ell_i \sin\theta_r \pm b_i \cos\theta_r) + (\ell_t \sin(\theta+\theta_r) \pm b_t \cos(\theta+\theta_r)) \\ \qquad \theta < 90°; \quad +\text{for } \theta_r < 90° \\ \qquad\qquad\qquad -\text{for } \theta_r > 90° \\ (\ell_i \sin\theta_r + b_i \cos\theta_r) + (\ell_t \sin(\theta+\theta_r) - b_t \cos(\theta+\theta_r)) \\ \qquad \theta > 90°; \quad \text{for all } \theta_r \end{cases} \tag{B-4}$$

The distance traveled in this frame of reference is

$$Y = tV_r = Z\, V_r/V_t \sin\theta, \quad \theta \neq 0° \text{ or } 180° \tag{B-5}$$

for a ship stream of width Z (i.e., in the channel 16 nautical miles).

For = 0, this distance is given by

$$Y = S\,\frac{V_r}{V_t} \tag{B-6}$$

APPENDIX A1.2.3.2

HYDROSTATIC TEST PROCEDURE

PREPARED BY

WILLIAMS BROTHERS ENGINEERING COMPANY

January, 1977

SECTION I

INTRODUCTION

1.0 GENERAL

1.1 Scope of Work

This test procedure was prepared by Williams Brothers Engineering Company for SOHIO to define the requirements and guidelines for a systematic procedure for hydrostatically testing the West Coast -- Mid-Continent Pipeline System. Because the actual hydrostatic testing would be conducted by a contractor, the procedures are described in terms of contractual requirements. The scope includes the following: Identification of test sections, cleaning, water fill, pressure test, pipeline repair, dewater, tie-in, pretest river crossings and tie-in pipe, recording of test results, and the presentation of certain engineering data and the procedure for quality analysis of test waters. These procedures can only be considered general at this time and are subject to specific changes.

The CONTRACTOR shall prepare a detailed description of his proposed procedure. The CONTRACTOR's procedure will require AGENT/OWNER approval thirty (30) days prior to the start of initial testing operations.

1.2 Construction Contract

All testing shall be conducted in accordance with this test procedure and the appropriate section of the Construction Contract.

1.3 Testing Crews

CONTRACTOR shall assign a separate construction crew with equipment for the testing operations. The crew and equipment shall have no other function than the support of test operations during the test.

1.4 Subcontract Option

If the hydrostatic testing is subcontracted by the Prime CONTRACTOR, the Prime CONTRACTOR shall furnish a job site representative during testing operations to ensure complete liaison between the CONTRACTOR and the testing subcontractor's organization. The job site representative shall have no other function during the test.

SECTION II

TESTING

1.0 IDENTIFICATION OF TEST SECTIONS

No attempt has been made in this document by the AGENT to identify intermediate test sectons, as this may limit the CONTRACTOR. However, major segments are identifiable in Table 1.2.3.2-26 of the FES.

1.1 Wall Thickness Changes

Pipe with wall thickness established by hydraulic gradients must be tested separately and shall not be combined in any other single test section.

1.2 Isolation of Test Sections

CONTRACTOR shall isolate the test sections with weld caps, temporary manifolds, and/or main-line valves, and shall install the necessary piping connecting to the test sections to allow passage of test water from one section to another.

The OWNER/AGENT shall furnish main-line pipe and weld caps as shown in Appendix B of this procedure for fabrication of manifolds by the CONTRACTOR. To prevent high stress on the pipe and risers on the test manifolds, there shall be no rigid connections between adjacent test manifolds.

1.3 Test Segment Identification

Changes in elevation along the pipeline have been determined so that testing may be carried out within the parameters set forth by the AGENT. Differences in elevation require the pipeline to be divided into intermediate sections so that excessive internal pressures will not be induced in the pipeline; so that the minimum pressure required is achieved, the elevations shall be such that it will establish a maximum of 99 percent,

the SMYS pressure range. In addition to the above, the CONTRACTOR shall consider proximity of the line to buildings and structures, the existence of road, river, rail, and canal crossings, the existence of natural or other hazards in the terrain being crossed, and the effect of washout on the surrounding areas, should any rupture or leaks occur. The program shall take into account the position of water sources and the possibility of requiring additional water from adjacent sections in the event of a blowout. Testing at each section shall start as soon as possible and shall be undertaken progressively throughout the construction of the pipeline, to ensure a minimum of hydrostatic testing at the end of the project.

1.4 Safety

The CONTRACTOR shall be responsible for implementing the safety procedures and practices in accordance with local, state and Federal codes. The above-mentioned safety precautions shall be supplemented by the following:

1. 'DANGER - PIPELINE UNDER TEST' and 'NO PARKING' signs shall be displayed at road crossings and other points where the public has access within 100 yards of the pipeline segment which is under test.

2. All landowners and tenants shall be notified of the time of the test, allowing for sufficient time for protection or relocation of livestock. Occupants of nearby buildings, stores, houses or other places of business in proximity of the pipeline segment to be tested, shall be warned when the testing will be carried out. Individual assessments shall be made for people living within 100 yards of the pipeline during the test period, including the provision of alternative accommodations, if necessary. Such accommodation shall be paid for by the OWNER, but shall be authorized by the AGENT prior to the test period.

3. The CONTRACTOR shall provide safety patrols, equipped with communications gear to provide information to the test headquarters, to

watch special points of hazard during the test, in particular, road, rail, and water crossings, and points of public access.

4. The CONTRACTOR shall have emergency standby crews available to locate and repair leaks and repair washouts or other damage.

5. The CONTRACTOR shall notify the local police or any other authority who may be involved that the testing will take place and shall comply with any safety requirements which they furnish to the CONTRACTOR.

6. The CONTRACTOR shall provide adequate safeguards to protect personnel conducting the hydrostatic tests. The pressurizing pump, pressure release valve and test equipment shall be located on the right-of-way, in the direction away from the section being tested, and as far away from the test end as possible.

2.0 CLEANING PIPELINE TEST SECTIONS

2.1 Each section of the pipeline shall be precleaned prior to introduction of the fill water.

2.1.1 A scraper pig shall be sent through the line first, to loosen any material, followed by a swabbing pig to clear the line. The CONTRACTOR shall use water as the propelling media. <u>CAUTION</u>: Compressed air should not be used in existing gas lines until enough water has been introduced into the line, thus eliminating any possibility of an explosion.

2.1.2 Following the swabbing pig the CONTRACTOR shall inject 100 barrels of methanol to wash the line of any residue from the previous flowing media.

Following the 100 barrels of methanol a second swabbing pig shall be used to contain the methanol and wipe the line clean of methanol and dissolved residue.

All materials from the above shall be diverted to a holding basin and not discharged to any source of drainage, where contamination of any waters could occur.

3.0 WATER FILL

3.1 Test Water Acquisition

The CONTRACTOR may avail himself to test water at source points designated in Table 1.2.3.2-26 of the FES. The CONTRACTOR shall bear the cost of all test water for hydrostatic testing. However, the CONTRACTOR is not restricted to these sources and may locate and obtain water from other sources at his discretion to facilitate the testing program. All cost for permitting alternate sources shall be borne by the CONTRACTOR. Any alternate sources for test water other than as specified in Table 1.2.3.2-26 must be approved by the AGENT.

The CONTRACTOR shall furnish all necessary equipment, including but not limited to pipe, pumps, filters, valves, etc., necessary to transport the test water to the test header connections which transfer water from one test section to another, and to dispose of the test water. All equipment supplied by the CONTRACTOR shall be subject to the approval of the AGENT/OWNER.

3.2 Chemical Analysis

The CONTRACTOR shall employ a certified laboratory for testing all influent and effluent water to ensure that the water meets permit standards for the discharge of test waters. This testing applies only for discharge from pipeline and not the transfer of water from one section to the next test section. Quality Analysis Procedures of hydrostatic test waters are presented in Subappendix D of this procedure.

3.3 Filtration

The fill water will be filtered prior to injection into the pipeline test section. Filtering may be required when water is transferred from one test section to another. The filter shall be of a quality to remove 99 percent of all particles, 92 micron in diameter or larger. This is equivalent to the capabilities of 100 x 100 mesh screens. The filter shall be of the Duplex cartridge type, provided with a means of cleaning either side without disconnecting the piping or interrupting the flow of testing media. The AGENT may request to examine the filter as he deems necessary.

3.4 Metering

A meter with adequate range and accurate within .1 percent shall be used to measure the quantity of fill water pumped into and released from the pipeline during any phase of the testing operation.

3.5 Fill Pumps

The water fill pump shall have a minimum capacity to move the pig ahead of the fill water at a minimum rate of 1 mph or 1.46 ft/sec. The air bleed valve shall be adjusted to ensure that the pig will not move ahead of the fill water at any time.

3.6 Scrapers

A pipeline displacement pig shall be launched ahead of the fill water. After approximately .75 mile of fill water, a second displacement pig shall be launched to reduce the contamination of the fill water. All main-line valves within the filling section must be opened for passage of the filler pigs and closed one-half way in order to fill the body cavity after passage of the pigs. The main-line valves will remain one-half open until the line has been depressurized.

The CONTRACTOR shall not discharge any test water that does not meet the permit standards until approval has been obtained from the AGENT and appropriate steps have been taken to contain the water for further treatment.

3.7 Water Fill

A continuous and even flow of water into the pipeline shall be maintained until the line is completely filled. The pumping system used for filling the test section shall be such as to reduce entrained air to a minimum by submerging the system line to maintain a flooded suction and to eliminate any vortexing in the suction.

4.0 PRESSURE TEST

4.1 Test Pressure

The pipeline shall be tested at specified pressures per section. This test pressure is to be achieved by a constant volume high pressure pump.

4.2 Instrumentation

Prior to the pressuring operation, the CONTRACTOR shall furnish and install a calibrated pressure and temperature recorder and one thermometer in each of the test headers. Refer to Subappendix A of this procedure for a detailed list of test instruments.

4.3 Stabilization Period and Test

After the AGENT approval of the filling operation, the pressure shall then be increased to the specified test pressure. When the test pressure is reached, the pump shall be shut down, the inlet block valves shall be closed, and the injection line shall be vented between the two injection block valves. A period of observation shall be made, to verify that the

test pressure is being maintained and that the test water temperature has stabilized. (The dead weight tester pressure gauge is a sensitive indication of pressure stability.) After the stabilization period, the pressure shall be adjusted. A continuous pressure recording chart will be maintained during the 24 hour test period and shall be required by the CONTRACTOR and verified by the AGENT. The pressure shall be at or above minimum test pressure, except for preinstallation test of fault, river, and floodplain crossings (discussed in following sections) for two hours. The chart record shall be substantiated by dead weight tester pressure gauge checks: one made at the beginning, at least one every half hour for the first four hours, every hour for 16 hours and every half hour for the last four hours of the 24 hour period. The pressure and temperature charts shall be ink marked, and noted at the point in time on the scribed gradients, each time a dead weight pressure gauge reading is made. The time, temperature of test medium, and the dead weight pressure gauge readings made for the 24 hour period shall be recorded. The cause of any pressure-temperature changes occurring during the hold period shall be noted. A pressure increase due to temperature increase during the hold period, shall be limited to the maximum permissible test pressure by a slow bleed-off. A pressure decrease due to temperature decrease during the hold period, shall be limited to the minimum permissible test pressure by injecting test medium into the section.

The time and amount of the pressure bleed off or increased (as measured by the dead-weight tester) by the volume and temperature, the liquid bleed off or injected test medium shall be noted. The temperature change of the test medium will likely occur during the hold period, and shall be estimated, and the starting hold test pressure will be determined accordingly. The hold test pressure shall commence at near maximum test pressure for an anticipated temperature drop, or near minimum test pressure for anticipated temperature increase. Should a leak or fracture occur the hold period shall be repeated, after repairs have been made, for a continuous 24 hours. All pressure readings noted for this record shall be the dead weight tester

pressure gauge readings. The test shall be considered acceptable, if the pressure is essentially stable, after adjustment for thermal variation.

4.4 Retest

The 24 hour pressure test shall be reinitiated after any repair, as stated above. Dewatering and refill in accordance with this procedure may be required by the AGENT/OWNER. Retests shall be conducted until it has been determined that the test results are acceptable by AGENT/OWNER.

5.0 PIPELINE REPAIR

5.1 Description of Repair

The CONTRACTOR shall locate, report and repair all hydrostatic test failures. In the event of a failure during testing, the CONTRACTOR shall execute the Pipeline Failure Report (Form 325). See Section III, Test Forms.

If the failure is in the seam of the pipe, the CONTRACTOR shall remove the entire joint in which the seam failure occurs and replace with a new joint. For other types of pipe failures, the CONTRACTOR shall replace the defective pipe as directed by the AGENT. The pipe removed shall be marked for orientation with respect to its position in the trench and with the approximate milepost and survey station of the failure. The CONTRACTOR shall not cut nor damage the edge of the pipe failure. The failure shall be photographed if possible. The CONTRACTOR shall transport damaged pipe to AGENT/OWNER's warehouse as directed by AGENT/OWNER.

5.2 Description of Weld Repairs

If a failure occurs in a girth weld, the CONTRACTOR shall repair, in accordance with approved weld repair procedures, as directed by the AGENT/OWNER. The location of the weld defect will determine the necessary steps which must be taken for the dewatering or lowering the level of water in the pipe, before repair can be made.

6.0 DEWATER

6.1 Displacement

Final dewatering of a test section shall take place only after hydrostatic testing has been accepted for each test section. After acceptance of the hydrostatic test the pressure shall immediately be lowered to atmospheric pressure. After depressurizing, emptying of the test section shall be conducted using one or more air propelled swabbing pigs, to discharge the water into an approved external disposal site or into adjacent test sections in accordance with an approved program and permits.

The water may be transferred from one test section to the next test section. This procedure shall be followed unless one of the following should occur:

1. Loss of water due to a line break.

2. Construction on an intermediate section not complete.

3. Contamination of the water making it unsuitable to test with.

4. Discharge permit limitations.

The test section, as presented in Table 1.2.3.2-26 of the FES, shows the total distance of each section and quantity of water (in barrels) contained, disposal location, and other data.

6.2 Disposition

Test water must meet the permit limitation before it can be disposed of into a stream, lake or run-off where it may commingle with other waters. If the discharge water does not meet the permit limitation, it shall be impounded into an approved holding basin. This basin must meet with the approval of the governing agency and the AGENT/OWNER.

The CONTRACTOR shall not discharge any test water that does not meet with the permit standard until approval has been obtained from the AGENT/OWNER and appropriate steps have been taken to contain the water for further treatment.

Where the hydrostatic test water is to be held for additional use and holding the test water in the pipeline is not practical, a storage pond may be constructed. Where deemed advisable, an impervious liner to prevent percolation will be utilized. Where the analysis of the test water indicates that some degree of treatment is required before discharge, the test water may be discharged into a municipal treatment system for treatment, before final discharge, or a pond could be constructed and the water impounded for further treatment or evaporation. The treatment applied to the impounded water would be appropriate to the contaminants present. The procedure for water treatment would be to impound the water and allow the suspended solids to settle to the bottom of the pond leaving a clear liquid which would be filtered prior to discharge. If oil and grease sheens are present on the impounding pond an oil separator or hay filter will be used in the discharge. All ponds constructed shall be filled to grade and the surface returned to its original state insofar as possible.

7.0 TIE-IN

The CONTRACTOR shall tie-in test sections to form a continuous pipeline between scraper stations. Tie-ins shall be made only after a successful hydrostatic test. All tie-in welds shall be radiographed.

8.0 PRETESTING RIVER AND FAULT CROSSINGS AND PIPE

8.1 Pipe for major river and fault crossings shall be pretested by the CONTRACTOR on the bank or in the ditch prior to the regular pipeline test. Pipe to be used for tie-ins and leak repair shall also be pretested by the CONTRACTOR to the pressure level of the section it is to be used. Test pressures shall be held for 24 hours, except for river crossings which will be pretested for two hours.

8.2 Subappendix C of this procedure provides information pertaining to major river and fault crossings to be pretested.

9.0 RECORDING TEST DATA AND REPORTS

9.1 Water volume injected into and released from each test section shall be recorded by the CONTRACTOR.

9.2 All pressure and temperature charts shall be clearly marked on the back with the following:

1. The date and the hour the chart was placed on and taken from the recorder.

2. The location of the recorder (elevation and MP).

3. The test section code or number.

4. Signatures of the AGENT/OWNER and CONTRACTOR representatives.

9.3 All test records and forms (see Section III, Test Forms) shall be furnished to the AGENT within twenty-four (24) hours of the completed test.

SECTION III

TEST FORMS

Compilation of all field test data shall be the responsibility of the CONTRACTOR's test technician. All test data shall be accurately recorded on the proper test forms and submitted to the AGENT's test supervisor for approval. Test forms are as follows:

Form 321 Test Engineer's Daily Report

Form 322 Hydrostatic Test Filling Log

Form 323 Hydrostatic Strength Test Report

Form 324 Hydrostatic Test Pressure -- Time Plot

Form 325 Pipeline Failure Report

Form 326 Hydrostatic Test -- Dewater and Drying Log

The CONTRACTOR's test technician shall prepare Form 321 for each day that test operations are being conducted. The test data compiled on this report shall be a brief resume of all test operations being conducted on the system as follows:

Acceptance or rejection of test completed to date.

Progress status of test being conducted.

Linear progress of tests completed to date.

Description to provide a documented record of any other events occurring during the test operations.

The CONTRACTOR's test technician shall prepare Forms 321, 322, 323, 324, and 326 to record hydrostatic strength test data and supplementary remarks to determine the acceptance or rejection of each test. This report shall be accompanied by applicable pressure and temperature recorder charts.

The CONTRACTOR's test technician shall prepare Form 325 for each failure that occurs during the testing operations with a detailed description of circumstances surrounding the failure. If possible, photographs of the failure shall be taken and accompany the report.

SUBAPPENDIX A

TEST INSTRUMENTS

Listed below are the test instruments which will be furnished by the CONTRACTOR for the testing operation. The quantity listed is for one test section as defined on the Alignment Profile shown in this section.

Item	Quantity/Test Section	Description
1	2	Dead weight tester, 50-2500 psi range with 1.0 psi increments of pressure. Complete with an approved mounting structure.
2	2	Portable 12" Ø chart size temperature recorder, temperature element to be fully compensated, range -20°F to 150°F, 24 hour clock wound chart drive, capillary inking marker, 15' S.S. armoured covered capillary tubing and a 7-1/2" S.S. Thermometer well, 3/4" NPT.
3	2	Portable 12" Ø chart size pressure recorder, range 0-2000 psi, 24 hr. clock wound chart drive, capillary inking marker, 15' of flexible armored covered hose rated at 5000 psi, w/1/4 NPT male connectors each end.
4	2	Same as item #3 except range to be 0-1000 psi.
5	4	0-2000 psi test gauges 6" Ø dial, 1/4" NPT male connection w/Plastic Face and maximum reset hand.

Item	Quantity/Test Section	Description
6	4	Same as item #5 except range to be 0-1000 psi.
7	4	ASTM Percussion Mercury filled Yellow Black thermometer with a range of -20°F to 150°F with 1/2°F increment. 3/4" NPT, 7-1/2" long SS Thermometers. Well with a 3/8" bore.

SUBAPPENDIX B

MATERIALS TO BE SUPPLIED BY AGENT

Listed below is the minimum amount of material believed to be required of the AGENTS in testing the sections of pipeline. This is subject to modification, and upon determination of available equipment, and the availability of test water and its discharge.

Item	No. Required	Description
1	Lin. Ft.	48", - 0.500 WT 2 x 60 pipe
2	Lin. Ft.	42", - 0.500 WT 2 x 60 pipe
3	Lin. Ft.	30", - 0.500 WT 2 x 60 pipe
4	4	48" .500 WT Y60 2 Weld Caps
5	12	42" .500 WT Y60 2 Weld Caps
6	8	30" .500 WT Y60 2 Weld Caps
7		48" Pigs -
8		42" Pigs -
9		30" Pigs -

SUBAPPENDIX C

RIVER AND FAULT CROSSINGS

NAME	M.P. to M.P.	Approx Length	Pipe Description	Type
Los Angeles River		600 feet	42" -0.5 x 60	Aerial
Compton Creek		350 feet	42" -0.500 x 60	Aerial
San Gabriel River	16.8-17.1	1300 feet	42" -0.500 x 60	Buried
Santa Ana River	64.7-65.8	1700 feet	42" -0.500 x 60	Buried
Colorado River	235.0-235.6	1170 feet	42" -0.500 x 60	Buried
San Andreas Fault	133.2-135.2	6200 feet	30" -0.500 x 60	Buried

SUBAPPENDIX D

QUALITY ANALYSIS PROCEDURE

I. WATER SOURCES

1.0 Treated or Untreated Municipal Waters

The pipeline runs from Long Beach, California, to Midland, Texas. Along the route, water will be acquired for hydrostatic testing. The acquired water shall be analyzed before use to determine its suitability as a testing media. This water shall be required to meet the NPDES permit requirements for discharge.

The prime source of hydrostatic test water will be treated or untreated municipal water with the following parameters:

pH	6.5 to 8.3
Total Suspended Solids	50 mg/l
Total Organic Carbon	22 mg/l

1.2 Surface Water and Impoundments

Surface water and impoundments are defined as lakes, rivers and streams. These waters shall be free of substances that will settle to form sludge deposits, free from floating debris, scum and other floating materials, free from objectionable odor and color, free of substances which are toxic or harmful to human, animal, plant, or aquatic life.

The quality of these waters as listed above and the parameters as stated below are satisfactory for test waters.

pH	6.5 to 8.3
Total Suspended Solids	50 mg/l
Total Organic Carbon	22 mg/l

BOD^5	20 mg/l
Phenols	0.1 mg/l
Oil and Grease	10 mg/l
Total Dissolved Solids	1,000 mg/l
Total Chlorides	500 mg/l
Total Sulphates	500 mg/l
Fecal Coliform	200 colonies/100 ml

This type water will correspond very nearly to "Class A" water, which is water fit for human contact, such as swimming, water-skiing and other recreational uses.

1.3 Groundwaters

Groundwater may be utilized where it meets the standards as set forth in 1.2 above. However, the use of groundwaters would be advisable only at certain times or seasons of the year when the water usage for irrigation would allow some draw on the system, or where there exists a surplus of water.

1.4 Other Water Sources

Any water source not defined above shall be analyzed in accordance with the following:

TDS

TSS

Settleable solids

BOD^5 @ 20°C

Oil and Grease

pH

Temperature

TOC (use in place of BOD[5])

COD

These analyses shall be presented to the AGENT for approval prior to filling operation, and comply with stipulations as outlined in NPDES discharge permit.

1.5 Additives

Test water shall be free of additives, inclusive of freeze depressants and/or inhibitors.

II. DISPOSITION OF DISCHARGE WATER

Prior to discharge of test water into a stream, lake or drainage system where it may commingle with other waters, it shall be in compliance with NPDES discharge permit. Discharge water in noncompliance will be impounded in holding basins approved by governing agency and held for treatment as required.

Previous hydrostatic testing results have indicated that the first 0.6 mile of fill water will contain the majority of the contaminants. Therefore it seems reasonable to postulate that during the filling of the pipeline with hydrostatic test water, the fill pig pushes the contaminants ahead of the water. This concentrated contaminant volume then moves essentially in a plug flow mode during the dewatering process. Where the hydrostatic test operation has the same receiving and source water, or the hydrostatic test effluent is dewatered from the same pipline end as it was filled, a rapid increase in contaminant concentrations of the effluent will occur at the end of the dewatering cycle. If, however, the dewatering or transfer occurs at

the opposite end of the filling operation, the highest concentration of contaminants in the effluent will occur during the first portion of the dewatering or transferring.

Based on the above, before the dewatering or transferring of the hydrostatic test water can occur, it shall be sampled and analyzed to determine level of contaminants using the figures listed below as a guideline:

pH	6.3 to 8.5
Temperature	100°F Max.
Suspended Solids	50 mg/l
Settleable Solids	.1 mg/l
BOD^5	20 mg/l
TOC (use in place of BOD^5)	22 mg/l
Oil and Grease	10 mg/l

Where the contaminants are high and the line is to be dewatered, the water shall be impounded until the quality of water will meet the discharge permit, then the balance of the hydrostatic test water can be discharged to the environment.

If the water is to be transferred from one test section to the next test section, the analysis of the water shall be reviewed; if it is determined that the contaminant concentrations are of a damaging level, then the AGENT will direct the water to be impounded. The water impoundment shall continue until a level of contaminant concentration (by analysis) has been reached and approved by the AGENT; then the balance of the test water may be transferred to the next section.

Where water has been impounded, it shall be analyzed to determine the necessary treatment required so that the water can be discharged back to the

environment. In all cases, the discharge of water to the environment must meet the standards as set forth in the NPDES permit.

III. SAMPLING

1.0 A representative sample shall be taken of the hydrostatic test water for analysis before discharge is to begin. If the water meets the permit limits then the discharge of the test water can commence.

1.1 For each 10,000 gallon discharge, a sample shall be taken and analyzed for compliance with the permit limitation.

1.2 Sample Identification

Each sample container shall be marked with the following:

Sample location
Date
Person taking sample
Time of collection
Type of sample
Method of sample collection
Weather condition
Measured flow at time of sample
Notes of unusual conditions

1.3 If an analysis of the hydrostatic test water, either the fill or discharge, is to be performed other than on the test site, the sample must be preserved and analyzed according to Subappendix Table D-1. The two tests which must be performed at the test site are the temperature and the dissolved oxygen tests.

SUBAPPENDIX TABLE D-1

Sample Preservation

PARAMETER	Sample Volume (ml's)	Container Material	Preservative	Maximum Holding Time[a]
pH	25	Plastic or glass	Cool, 4°C or determined on site	6 hours
BOD^5	1,000	Plastic or glass	Cool, 4°C	6 hours
Phenols	500	Glass only	Cool, 4°C, add H^3PO^4 to pH<4 + 1.0 gm cu SO^4/1	24 hours
Oil and Grease	1,000	Glass only	Cool, 4°C, add H^2SO^4 to pH<2	24 hours
Turbidity	100	Plastic	Cool, 4°C	7 days
Total Suspended Solids	100	Plastic or glass	Cool, 4°C	7 days
Total Organic Carbon	25	Plastic or glass	Cool, 4°C, add H^2SO^4 to pH<2	24 hours
COD	50	Plastic or glass	Add H^2SO^4 to pH<2	7 days
Total Dissolved Solids	100	Plastic or glass	Cool, 4°C	7 days
Total Alkalinity	100	Plastic or glass	Cool, 4°C	24 hours
Total Calcium Hardness as $CaCO^3$	100	Plastic or glass	Cool, 4°C	7 days
Chloride	50	Plastic or glass	Not required	7 days
Sulfate	50	Plastic or glass	Cool, 4°C	7 days
Fecal coliform	1,000	Glass and sterilized	Cool, 4°C	6 hours
Temperature	-	Plastic or glass	Determined on site	No holding
Dissolved Oxygen	300	Glass only	Determined on site	No holding

[a] Maximum elapsed holding time; from time of sampling to start of the analysis.

IV. ANALYTICAL METHODS

Subappendix Table D-2 gives the sources of analytical methods that may be required. This table also equates "EPA-Manual of Methods for Chemical Analysis of Water and Waste," 1974 Edition to other methods of analysis.

SUBAPPENDIX TABLE D-2

Sources of Analytical Methods

PARAMETER	EPA Procedural Reference[a]	Source of Method	Source of Alternate Method
pH	Storet No. 00400, P. 239	Standard Methods, 13th Ed. Method No. 144A, P. 276	ASTM Standards, Part 21 Method D-1293-65 (1973), P. 186
BOD^5	Storet No. 00310, P. 11	Standard Methods, 13th Ed. Method No. 489, P. 489	
Phenols	Storet No. 32730, P. 241	Standard Methods, 13th Ed. Method No. 222, P. 501	
Oil and Grease	Storet No. 00556, P. 229	Standard Methods, 13th Ed., Method No. 137, P. 254	EPA Manual,[a] Storet No. 00556, P. 229
Turbidity	Storet No. 00076, P. 295	EPA Manual,[a] Storet No. 00076, P. 295	
Total Suspended Solids	Storet No. 00530, P. 268	Standard Methods, 13th Ed., Method No. 224C, P.537	EPA Manual,[a] Storet No. 00530, P. 268

[a] EPA -- "Manual of Methods for Chemical Analysis of Water and Waste," 1974 Edition.

SUBAPPENDIX TABLE D-2 (Continued)

PARAMETER	EPA Procedural Reference[a]	Source of Method	Source of Alternate Method
Total Organic Carbon	Storet No. 00680, P. 236	EPA Manual[a] P. 236[b]	
COD 15-2000 mg/1	Storet No. 00340, P. 20	Standard Methods, 13th Ed., Method No. 220, P. 495	ASTM Standards, Method D-1252-67 (1973) P. 470
COD (low level) 0-15 mg/1	Storet No. 00335, P. 21	EPA Manual[a]	
Total Dissolved Solids	Storet No. 70300, P. 266	Standard Methods, 13th Ed., Method No. 224E, P. 539	
Total Alkalinity	Storet No. 00410 (pH 4,5), P. 3	Standard Methods, 13th Ed., Method No. 102, P. 52	
Total calcium Hardness as $CaCO^{3}$	Storet No. 00900, P. 68	Standard Methods, 13th Ed., Method No. 110C, P. 84	
Chloride	Storet No. 00940, P. 29	ASTM Standards, Part 23, Method 512-67, refree Method A (1973)	

[b] Analyzer similar or equal to Beckman Model 915 Total Carbon Analyzer.

SUBAPPENDIX TABLE D-2 (Continued)

PARAMETER	EPA Procedural Reference[a]	Source of Method	Source of Alternate Method
Sulfate	Storet No. 00945, P. 283	Standard Methods, 13th Ed., Method No. 156A, P. 331	ASTM Standards, Method D-516-68 (1973) P. 425
Fecal Coliform		Standard Methods, 13th Ed., Method No. 408B, P. 684	
Temperature	Storet No. 00010, P. 286	Standard Methods, 13th Ed., Method No. 162, P. 384	
Dissolved Oxygen	Storet No. 00290	DPA Manual[a]	

APPENDIX A2.1.3.2

Geology

Table A2.1.3.2-1

Major Historic Earthquakes and Surface Faulting in Southern California

FAULT MAP SYMBOL	Fault Name or Location and Date	Richter Magnitude of Associated Earthquake	Length of Surface Rupture --- Displacement Main Fault (feet)	Remarks	Principal References
1852	Southern Calif. 27-30 November 1852 (Big Pine Fault)		<30 mi	Disturbed area over 300 sq. mi., many aftershocks, epicenter in Ventura County.	Coffman and von Hake, 1973; Hill and Dibblee, 1953; Townley and Allen, 1939
1855 D[a]	Los Angeles County, 10 or 11 July 1855 (Newport-Inglewood Fault)			4 shocks felt in about 12 sec., 20 buildings damaged, submarine origin suggested by sea waves.	Coffman and von Hake, 1973; Townley and Allen, 1959
1857 A	Fort Tejon, 8-9 January 1857 (San Andreas Fault)	8(+)	200 mi --- approx 20	Buildings and large trees thrown down, artesian wells in Santa Clara Valley (near Ventura) ceased to flow, Intensity X-XI, two killed, streambeds changed.	Coffman and von Hake, 1973; Lawson et al., 1908; Allen, St. Amand, Richter, and Nordquist, 1965; Wood, 1955; Townley and Allen, 1939; Greensfelder, 1971

Source: Woodward-Lundgren, 1974.

[a] For explanation of lettered suffixes A, B, C, and D, refer to Figure 2.1.3.2-1.

Table A2.1.3.2-1 (Continued)

FAULT MAP SYMBOL	Fault Name or Location and Date	Richter Magnitude of Associated Earthquake	Length of Surface Rupture --- Displacement Main Fault (feet)	Remarks	Principal References
1868 A	Dos Palmas May, 1868 (San Andreas Fault)			Long fissure opened in earth(?), possible Intensity IX-X.	Coffman and von Hake, 1973; Townley and Allen, 1939; Preston, 1893
1872 A 1872	Owens Valley 26 March 1872 (Owens Valley Fault)	8.3 (est)	60+ mi --- 23	Intensity X-XI, 27 killed, 23-ft-scarps, horizontal motions up to 20 ft, severe aftershocks.	Coffman and von Hake, 1973; Whitney, 1888; Hobbs, 1910; Bateman, 1969; Bonilla, 1967; Slemmons, Cluff, and Carver, 1968; Richter, 1958
1890 D	Mono Lake 10 August(?) 1890			Strong shock, date uncertain, Mono Lake agitated, sulfurous fumes, boiling water.	Coffman and von Hake, 1973; Townley and Allen, 1939
1893 C	Northwest of Los Angeles			35 mi. NW of Los Angeles, all chimneys wrecked, earth fissured, boulders shaken down hillsides, aftershocks continued for days.	Coffman and von Hake, 1973; Townley and Allen, 1939

Table A2.1.3.2-1 (Continued)

FAULT MAP SYMBOL	Fault Name or Location and Date	Richter Magnitude of Associated Earthquake	Length of Surface Rupture --- Displacement Main Fault (feet)	Remarks	Principal References
1899 B	San Jacinto and Hemet, 25 December 1899 (San Jacinto Fault)			In Hemet, all brick buildings damaged severely, 6 killed at Saboda, cracked walls and threw down chimneys at Riverside, frequent aftershocks, Intensity X-XI.	Coffman and von Hake, 1973; Danes, 1907; Allen, St. Amand, Richter, and Nordquist, 1965; Sharp, 1967; Townley and Allen, 1939
1916 B	Tejon Pass 22 October 1916 (San Andreas - Garlock Fault)	6.0	<200 ft ---	Rocks shaken down to roads.	Coffman and von Hake, 1973; Townley and Allen, 1939
1917 C	Owens Valley 6 July 1917 (Owens Valley Fault)		<100 ft ---	Chimneys cracked, rocks rolled down hills, 9 shocks in 3 days.	Coffman and von Hake, 1973; Townley and Allen, 1939
1918 C	San Jacinto and Hemet, 21 April 1918, (San Jacinto Fault)	6.8		Intensity VI-VII, aftershocks severe, San Jacinto and Hemet suffered extensive damage, slides.	Coffman and von Hake, 1973; Sharp, 1967; Townley and Allen, 1939; Fraser, 1931; Wood and Heck, 1966

Table A2.1.3.2-1 (Continued)

FAULT MAP SYMBOL	Fault Name or Location and Date	Richter Magnitude of Associated Earthquake	Length of Surface Rupture --- Displacement Main Fault (feet)	Remarks	Principal References
1918	Corona 22 April 1918 (San Jacinto Fault Zone)			Chimneys cracked, plaster thrown down.	Coffman and von Hake, 1973; Townley and Allen 1939
1918 D	Riverside County 6 June 1918 (San Jacinto Fault)			4-1/2 mi. SW of Hemet, shock cracked ground and plaster, loosened rock, a strong aftershock on April 21.	Coffman and von Hake, 1973; Sharp, 1967; Townley and Allen, 1939
1920 D	Inglewood 21 June 1920 (Newport-Inglewood Fault)	4.9		Damage to poorly built structures only, Intensity VIII-IX.	Coffman and von Hake, 1973; Townley and Allen, 1939
1933 D	Long Beach 10 March 1933 (Newport-Inglewood Fault)	6.3		Little evidence of ground movement, no fault displacement visible, approx. 115 dead, submarine origin, poor structural work and water-soaked alluvium increased damage, unconsolidated and made ground failed. $40 million damage, Intensity VII-IX.	Heck and Bodle, 1968; Coffman and von Hake, 1973

Table A2.1.3.2-1 (Continued)

FAULT MAP SYMBOL	Fault Name or Location and Date	Richter Magnitude of Associated Earthquake	Length of Surface Rupture --- Displacement Main Fault (feet)	Remarks	Principal References
1940 A	Southeast of El Centro, 18 May 1940 (Imperial Fault)	7.1	40 mi --- 15 hor. 4 vert.	Intensity X, affected 60,000 sq. mi., serious interruption to water service, 9 dead, $6 million damage, 40% of buildings at Brawley damaged.	Coffman and von Hake, 1973; Ulrich, 1941
1941 D	Gardena Area 21 October 1941	4.9		Oil field damage, windows broken, chimneys twisted, $10,000 damage.	Coffman and von Hake, 1973
and 1941 D	Torrance-Gardena Area, 14 November 1941 (Newport-Inglewood Fault)	5.4		$1 million damage, 50 buildings damaged pipeline and natural gas pipeline broke, chimneys twisted or broken, 201 oil tanks demolished.	Coffman and von Hake, 1973

Table A2.1.3.2-1 (Continued)

FAULT MAP SYMBOL	Fault Name or Location and Date	Richter Magnitude of Associated Earthquake	Length of Surface Rupture --- Displacement Main Fault (feet)	Remarks	Principal References
1946 C	Sierra Fault 15 March 1946	6.25		Pipes broken in Bakersfield, considerable damage to wood, brick, masonry, and concrete at Onyx, cracks in ground, some pipes broken.	Coffman and von Hake, 1973
1947 A	Manix Fault	6.4	1 mi --- .25	A trestle settled 2 ft., highways cracked and slumped, Mojave River water level raised, landslides in Afton Canyon, surface faulting may be secondary to concealed right-lateral rupture.	Coffman and von Hake, 1973; Richter, 1958
1948 D	Desert Hot Springs	6.5		Slumping of cliffs and riverbanks, landslides, minor structural damage mostly through separation of structural parts, but some walls also severely damaged.	Coffman and von Hake, 1973

Table A2.1.3.2-1 (Continued)

FAULT MAP SYMBOL	Fault Name or Location and Date	Richter Magnitude of Associated Earthquake	Length of Surface Rupture --- Displacement Main Fault (feet)	Remarks	Principal References
1949	Harpter Valley Fault, 1949	creep	2 mi	May be related to subsidence.	Bonilla, 1970; Hill, 1954; Manning, 1968; Park, 1964; Allen et al., 1965
1950 D	San Andreas Fault 29 July 1950	5.4		$50,000 damage, sand boils, irrigation ditch banks sloughed, concrete stand pipes broke, a railroad bridge shifted 6 to 8 in.	Coffman and von Hake, 1973
1950 D	San Andreas Fault 1 August 1950	4.7		Aftershock of July 29, additional earth boils started in areas previously affected, ground fissures opened wider.	Coffman and von Hake, 1973
1951 A	Superstition Hills Fault 23 January 1951	5.6	2± mi	Intensity VII, canal banks cracked, 100 ft. of ground settled 1 in., strike-slip indicated by en echelon fractures but amount of displacement unknown.	Coffman and von Hake, 1973 Dibblee, 1954; Allen et al., 1965; Allen, St. Amand, Richter, and Nordquist, 1965

Table A2.1.3.2-1 (Continued)

FAULT MAP SYMBOL	Fault Name or Location and Date	Richter Magnitude of Associated Earthquake	Length of Surface Rupture --- Displacement Main Fault (feet)	Remarks	Principal References
1951 D	San Andreas Fault 5 December 1951	4.5	100 ft	Crack 100 ft by 1.5 in. appeared in gravel road, artesian well spurted water 10 ft, bank damage to canals, Imperial Valley.	Coffman and von Hake, 1973
1952 A	Kern County 21 July 1952 (White Wolf Fault)	7.7	33 mi discontinuous --- 2.5	10 ft of sloping across main fault zone at one locality. Shaking or regional adjustment of strain produced .5 ft vertical faulting for 400 ft along Garlock Fault, 20 mi. from White Wolf Fault, Intensity XI, rails shifted, 12 persons killed, reinforced concrete tunnels cracked and collapsed, pipelines damaged, 180 aftershocks of magnitude 4.0 or more, $50 million damage.	Buwalda and St. Amand, 1955; Dibblee, 1955; Kupfen and others, 1955; Richter, 1958; Coffman and von Hake, 1973; Warne, 1965

Table A2.1.3.2-1 (Continued)

FAULT MAP SYMBOL	Fault Name or Location and Date	Richter Magnitude of Associated Earthquake	Length of Surface Rupture --- Displacement Main Fault (feet)	Remarks	Principal References
1952 D	Bakersfield 22 August 1952	5.8		Intensity VIII, 2 killed, $10 million damage, many brick buildings destroyed.	Coffman and von Hake, 1973
1953 D	Superstition Hills Fault	5.5		1/2 mi. of canal bank cracked, landsliding, felt from Phoenix to San Diego and Niland to Mexicali Valley (Baja), strong aftershocks on June 14.	Coffman and von Hake, 1973
1954 D	White Wolf Fault 12 January 1954	5.9		Magnitude 5 aftershock (?) on January 27, walls cracked in Los Angeles, Stockton and Bakersfield, felt throughout San Joaquin Valley into Imperial Valley.	Coffman and von Hake, 1973
1957 D	San Andreas Fault 25 April 1957	5.2		Aftershocks of magnitude 2.9 to 5.1, slight damage at Brawley, El Centro, and Westmerland.	Coffman and von Hake, 1973

Table A2.1.3.2-1 (Continued)

FAULT MAP SYMBOL	Fault Name or Location and Date	Richter Magnitude of Associated Earthquake	Length of Surface Rupture --- Displacement Main Fault (feet)	Remarks	Principal References
1966 A	Imperial Fault 4 March 1966	3.6	6 mi --- 0.05	Horizontal displacement.	Coffman and von Hake, 1973; Brune and Allen, 1967a, 1967b
1968 A	Coyote Creek Fault 8 April 1968	6.5	200 ft	Main shock of a series, felt in California, Arizona and Nevada, 5.2 magnitude aftershock, triggering of minor ground ruptures on neighboring Superstition Hills Fault, Imperial Fault, and Banning. Mission Creek portion of San Andreas Fault, transformer shifted, pipeline cracked.	Coffman and von Hake, 1973
1968	Calexico Area 8 April 1968 (Imperial Fault)	4.7		Aftershock of April 8.	Coffman and von Hake, 1973
1968	Superstition Hills Fault, 22 May 1968	4.4	creep	Aftershock of April 8.	Coffman and von Hake, 1973

Table A2.1.3.2-1 (Continued)

FAULT MAP SYMBOL	Fault Name or Location and Date	Richter Magnitude of Associated Earthquake	Length of Surface Rupture --- Displacement Main Fault (feet)	Remarks	Principal References
1968	Imperial Fault, 1968		creep	Right lateral movement.	Miller et al., 1970
1971 A	San Fernando 9 February 1971	6.6	10 mi --- approx. 3.5 vert. 3.5 hor.	59 deaths and $500 million damage resulted from this earthquake.	USGS Professional Paper 733

Table A2.1.3.2-2

Summary of Quaternary Faults in the Vicinity of the Pipeline Route

Arizona - New Mexico - Texas

FAULT	Location	Type of Displacement	Period of Epoch of Last Movement	Fault Trace Crosses Pipeline Route
Arizona				
Plomosa Mountains	Near California-Arizona border	Right lateral strike-slip	Tertiary/Quaternary	Yes (concealed)
Little Horn Mountains	Near California-Arizona border	Right lateral strike-slip	Quaternary	No
Pirate	San Pedro rift near San Pedro River	Oblique right lateral/normal	Quaternary	Possible (concealed)
San Manuel	San Pedro rift near San Pedro River	Oblique right lateral/normal	Tertiary/Quaternary	No
Mammoth	San Pedro rift near San Pedro River	Oblique right lateral/normal	Tertiary/Quaternary	Yes (concealed)
New Mexico				
Dos Cabezas Mountains	North of Dos Cabezas Mountains	Dip-slip/normal	Tertiary/Quaternary	Yes (inferred location)
Cambray	South of Cambray	Dip-slip/normal	Pleistocene	Possible (concealed)
West/East Robledo Mountains	Southwest of Las Cruces	Dip-slip/normal	Pleistocene	Yes (inferred location)
Afton	Southwest of Las Cruces	Dip-slip/normal	Pleistocene	No

Source: Holmes & Narver, 1976.

Table A2.1.3.2-2 (Continued)

Summary of Quaternary Faults in the Vicinity of the Pipeline Route

Arizona - New Mexico - Texas

FAULT	Location	Type of Displacement	Period of Epoch of Last Movement	Fault Trace Crosses Pipeline Route
Texas				
Mesilla Valley	South of Anthony	Dip-slip/normal	Pleistocene	Yes (concealed)
West Franklin Mountains	Western boundary of Franklin Mountains	Dip-slip/normal	Pleistocene	Yes (concealed)
East Franklin Mountains	Eastern boundary of Franklin Mountains	Dip-slip/reverse	Pleistocene	Yes (concealed)
Diablo Plateau	Short distance east of Hueco Mountains	Dip-slip/normal	Pleistocene	Yes (inferred location)
Salt Basin	West side of Salt Basin	Dip-slip/normal	Pleistocene	No
Guadalupe Mountains	East side of Salt Basin	Dip-slip/normal	Pleistocene/"young" Quaternary	Yes

APPENDIX A2.1.4.1

Soil Samplings and Related Tables

Table A2.1.4.1-1

Sediment Chemistry Results of Core Samples

LAB NO.	Station	Sample Depth, ft MLLW	Meas. Length (inches)	Fraction Retained on #200 Sieve	Fraction Dry Solids	Cadmium (Cd) mg/kg	Lead (Pb) mg/kg	Zinc (Zn) mg/kg	Mercury (Hg) mg/kg	Oil & Grease (Soxhlet extr. method) mg/kg
1[a]	1	56-58	18	0.141	0.580	1.7	58	240[b]	1.2	2,500[b]
2		58-60	31	0.228	0.748	0.56	19	97	0.23	45
3		60-63	20	0.129	0.750	0.85	15	92	0.27	10
4		63-65	31	0.409	0.783	0.46	14	74	0.29	10
5	2	57-59	16	0.136	0.599	2.0	57	300[b]	1.6[b]	1,700
6		59-61	24	0.160	0.613	5.1[b]	100	480[b]	2.5[b]	5,600[b]
7		61-62	10	0.309	0.727	1.2	57	200	0.89	1,700

Source: Long Beach Harbor Consultants, 1976.

[a] Reported results are the average of seven replicate samples.

[b] Exceeds proposed Environmental Protection Agency Region IX concentration limits.

Table A2.1.4.1-1 (Continued)

LAB NO.	Station	Sample Depth, ft MLLW	Meas. Length (inches)	Fraction Retained on #200 Sieve	Fraction Dry Solids	Cadmium (Cd) mg/kg	Lead (Pb) mg/kg	Zinc (Zn) mg/kg	Mercury (Hg) mg/kg	Oil & Grease (Soxhlet extr. method) mg/kg
8	3	57-59	12	0.018	0.602	1.4	89	260[b]	2.6	2,800[b]
9		59-62	33	0.018	0.591	2.4	54	300[b]	1.1	1,800
10		62-65	33	0.100	0.666	0.96	22	120	0.32	630
11	4	54-56	24	0.112	0.605	1.6	41	230[b]	1.1	3,900[b]
12		56-60	56	0.016	0.665	0.93	26	130	0.33	10
13		60-62	17	0.260	0.711	1.1	14	94	0.26	10
14		62-64	21	0.417	0.760	0.49	11	77	0.20	450
15	5	59-61	14	0.121	0.760	1.0	14	97	0.23	660
16		61-64	22	0.185	0.523	1.4	19	20	0.40	1,400
17		64-66	19	0.316	0.705	1.8	12	75	0.20	680
18[a]		66-69	24	0.387	0.772	1.0	12	74	0.22	170

Table A2.1.4.1-1 (Continued)

LAB NO.	Station	Sample Depth, ft MLLW	Meas. Length (inches)	Fraction Retained on #200 Sieve	Fraction Dry Solids	Cadmium (Cd) mg/kg	Lead (Pb) mg/kg	Zinc (Zn) mg/kg	Mercury (Hg) mg/kg	Oil & Grease (Soxhlet extr. method) mg/kg
19		69-74	--[c]	-----	-----	---	--	--	----	---
20	6	46-48	23	0.194	0.714	7.8[b]	18	10	0.26	740
21		48-50	10	0.023	0.569	5.2[b]	110	90[b]	0.21	5,100[b]
22		50-53	--	-----	-----	--	---	--	----	-----
23		53-55	--	-----	-----	---	---	--	----	-----
24	7	47-49	12	0.059	0.716	2.6[b]	20	00	0.33	870
25		49-50	--	-----	-----	---	--	--	----	----
26		50-53	--	-----	-----	---	--	--	----	----
27		53-55	--	-----	-----	---	--	--	----	----

[c] Data unavailable.

Table A2.1.4.1-1 (Continued)

LAB NO.	Station	Sample Depth, ft MLLW	Meas. Length (inches)	Fraction Retained on #200 Sieve	Fraction Dry Solids	Cadmium (Cd) mg/kg	Lead (Pb) mg/kg	Zinc (Zn) mg/kg	Mercury (Hg) mg/kg	Oil & Grease (Soxhlet extr. method) mg/kg
28	8	38-40	24	0.122	0.626	2.0	47	60	0.51	3,400[b]
29		40-42	32	0.157	0.671	1.4	24	10	0.19	1,600
30		42-45	32	0.174	0.736	0.66	14	73	0.11	1,300
31		45-48	32	0.449	0.729	1.0	8.1	44	0.028	3,200[b]
32		48-53	20	0.601	0.794	0.94	10	37	0.30	160
33		53-58	--	-----	-----	----	---	--	----	----
34		58-62	38	0.667	0.758	1.2	6.0	44	0.12	4,200[b]
35	9	65-67	24	0.450	0.692	0.81	20	93	0.30	1,300
36		67-70	35	0.459	0.773	0.67	15	82	0.39	270
37		70-73	--	-----	-----	----	--	--	----	---
38		73-75	--	-----	-----	----	--	--	----	-----
39		75-80	--	-----	-----	----	--	--	----	-----
40	11	31-33	24	0.347	0.737	0.66	30	66	0.14	2,500[b]
41		33-35	32	0.516	0.716	0.83	14	34	.019	1,400

Table A2.1.4.1-1 (Continued)

LAB NO.	Station	Sample Depth, ft MLLW	Meas. Length (inches)	Fraction Retained on #200 Sieve	Fraction Dry Solids	Cadmium (Cd) mg/kg	Lead (Pb) mg/kg	Zinc (Zn) mg/kg	Mercury (Hg) mg/kg	Oil & Grease (Soxhlet extr. method) mg/kg
42		35-38	29	0.563	0.804	0.43	8.2	28	.016	690
43		38-41	32	0.629	0.795	0.90	9.0	35	.020	2,400[b]
44		41-46	38	0.732	0.813	0.72	9.4	30	.014	1,500
45		46-51	12	0.710	0.790	0.98	10	42	0.097	3,200
46		51-61	28	0.384	0.732	1.7	7.5	68	0.20	1,300
47		61-71	28	0.079	0.692	1.6	7.4	69	0.30	890
48		71-81	9	0.698	0.814	0.91	2.5	35	0.15	1,800
49		81-88	24	0.472	0.790	0.92	11	49	0.086	1,600
50	12	49-51	24	0.497	0.757	0.45	11	60	0.21	180
51		51-54	32	0.436	0.654	0.88	33	21	0.74	770
52		54-56	34	0.213	0.668	1.0	34	19	0.44	870
53		56-59	32	0.169	0.766	0.57	12	79	0.31	400
54		59-64	38	0.451	0.793	0.40	11	60	0.063	1,400
55		64-69	36	0.422	0.709	1.3	10	69	0.057	2,300[b]
56		77-79	26	0.657	0.769	0.69	8.6	52	0.038	1,500
57		85-87	27	0.664	0.752	0.62	6.8	31	0.026	4,000[b]

Table A2.1.4.1-1 (Continued)

LAB NO.	Station	Sample Depth, ft MLLW	Meas. Length (inches)	Fraction Retained on #200 Sieve	Fraction Dry Solids	Cadmium (Cd) mg/kg	Lead (Pb) mg/kg	Zinc (Zn) mg/kg	Mercury (Hg) mg/kg	Oil & Grease (Soxhlet extr. method) mg/kg
58	13	47-49	18	0.454	0.673	0.46	9.0	57	0.15	890
59		49-52	32	0.415	0.780	0.56	12	75	0.26	900
60		52-54	29	0.358	0.745	0.76	12	56	0.11	120
61		54-57	32	0.462	0.802	0.53	7.8	51	0.10	650
62		57-62	36	0.451	0.793	0.46	5.9	34	0.12	1,700
63		62-67	--	-----	-----	----	--	--	----	----
64		71-73	36	0.145	0.724	0.38	4.4	74	0.18	6,400[b, d]
65		80-82	19	0.715	0.778	0.10	4.0	29	0.17	610
66	14	56-58	16	0.076	0.551	1.1	44	106	0.29	460
67		58-61	24	0.278	0.767	.69	15	59	0.10	840
68		61-63	30		0.865	0.72	7.9	29	0.037	1,600
69		63-66	22	0.439	0.879	0.56	10	51	0.074	1,000
70		66-71	27	0.470	0.863	0.72	15	62	0.039	1,300

[d] Doubtful results.

Table A2.1.4.1-1 (Continued)

LAB NO.	Station	Sample Depth, ft MLLW	Meas. Length (inches)	Fraction Retained on #200 Sieve	Fraction Dry Solids	Cadmium (Cd) mg/kg	Lead (Pb) mg/kg	Zinc (Zn) mg/kg	Mercury (Hg) mg/kg	Oil & Grease (Soxhlet extr. method) mg/kg
71		71-76	--	-----	-----	---	--	---	----	----
72		78-82	36	0.725	0.834	0.26	6.2	39	0.14	800
73		86-93	--	-----	-----	---	--	---	----	----
74	15	36-38	24	0.126	0.655	1.1	71	140	0.28	1,400
75		38-41	30	0.530	0.779	0.44	16	35	0.020	2,300[b]
76		41-43	30	0.611	0.795	0.58	7.1	27	0.045	750
77		43-46	31	0.645	0.782	0.58	7.5	27	0.053	410
78		46-51	36	0.623	0.806	0.57	11	35	0.052	620
79		51-56	--	-----	-----	---	--	---	----	----
80		63-66	34	0.598	0.727	0.67	9.7	37	0.020	1,500
81		65-76	24	0.670	0.715	0.33	6.7	20	0.028	1,900
82		84-86	--	-----	-----	---	--	---	----	----
83	16	36-38	24	0.080	0.675	0.66	10	56	0.23	2,800[b]

Table A2.1.4.1-1 (Continued)

LAB NO.	Station	Sample Depth, ft MLLW	Meas. Length (inches)	Fraction Retained on #200 Sieve	Fraction Dry Solids	Cadmium (Cd) mg/kg	Lead (Pb) mg/kg	Zinc (Zn) mg/kg	Mercury (Hg) mg/kg	Oil & Grease (Soxhlet extr. method) mg/kg
84		38-41	25	0.191	0.692	1.0	28	71	0.060	1,800
85		41-43	33	0.515	0.769	0.63	13	35	0.026	1,700
86		43-46	36	0.641	0.796	1.2	14	27	0.014	1,000
87		46-51	36	0.541	0.784	0.80	12	48	0.036	1,300
88		51-56	36	0.606	0.788	0.39	11	51	0.16	1,500
89		56-66	32	0.661	0.793	0.63	8.5	47	0.046	2,200[b]
90		66-76	28	0.703	0.782	0.59	8.0	39	0.029	530
91		76-82	--	-----	-----	---	--	---	-----	----
92	17	40-42	24	0.039	0.648	1.5	53	130	0.25	1,600
93		42-44	33	0.084	0.647	1.3	32	93	0.19	3,500[b]
94		44-47	33	0.450	0.788	0.62	14	34	0.036	1,500
95		47-50	31	0.582	0.796	1.2	12	31	0.074	1,000
96		50-55	36	0.647	0.765	0.88	11	41	0.039	1,100
97		55-60	35	0.206	0.833	0.86	13	59	0.089	843
98		60-70	25	0.589	0.803	0.62	7.8	44	0.035	2,400[b]

Table A2.1.4.1-1 (Continued)

LAB NO.	Station	Sample Depth, ft MLLW	Meas. Length (inches)	Fraction Retained on #200 Sieve	Fraction Dry Solids	Cadmium (Cd) mg/kg	Lead (Pb) mg/kg	Zinc (Zn) mg/kg	Mercury (Hg) mg/kg	Oil & Grease (Soxhlet extr. method) mg/kg
99		70-80	21	0.666	0.771	0.63	6.3	35	0.062	1,200
100		80-86	18	0.219	0.808	0.92	14	71	0.089	920
101	18	46-48	24	0.375	0.752	0.62	15	57	0.077	<20
102		48-51	33	0.576	0.782	0.54	9.8	30	0.041	780
103		51-53	37	0.669	0.784	0.56	11	36	0.024	500
104		53-56	32	0.713	0.821	0.51	9.1	32	0.030	180
105		56-61	36	0.823	0.840	0.55	6.1	18	0.029	380
106		61-66	36	0.657	0.812	0.41	8.8	36	0.043	140
107		73-76	35	0.184	0.740	0.98	12	65	0.078	2,400[b]
108		81-83	20	0.022	0.713	1.3	18	100	0.13	2,800[b]
109	19	62-64	26	0.314	0.661	0.76	31	94	0.20	760
110		64-67	20	0.249	0.718	0.73	24	82	0.20	650
111		67-69	33	0.258	0.817	0.55	17	66	0.16	310
112		69-72	32	0.456	0.845	0.31	16	58	0.12	1,500
113		72-77	35	0.728	0.842	0.26	18	38	0.043	560

Table A2.1.4.1-1 (Continued)

LAB NO.	Station	Sample Depth, ft MLLW	Meas. Length (inches)	Fraction Retained on #200 Sieve	Fraction Dry Solids	Cadmium (Cd) mg/kg	Lead (Pb) mg/kg	Zinc (Zn) mg/kg	Mercury (Hg) mg/kg	Oil & Grease (Soxhlet extr. method) mg/kg
114		77-82	--	-----	-----	---	--	---	----	----
115		82-87	--	-----	-----	---	--	---	----	----
116	20	70-72	24	0.043	0.481	1.8	64	180	0.32	2,500[b]
117		72-75	33	0.258	0.698	0.64	25	73	0.18	1,600
118		75-77	44	0.336	0.873	0.75	14	17	0.040	1,500
119		77-80	24	0.311	0.840	0.87	17	70	0.075	1,500
120		80-85	40	0.726	0.863	0.40	11	34	0.086	1,400
121		85-90	--	-----	-----	---	--	---	----	----
122		90-95	--	-----	-----	---	--	---	----	----
123	21	71-73	25	0.020	0.499	2.0	64	180	0.38	2,500[b]
124		73-76	34	0.267	0.702	0.98	25	72	0.11	1,900
125		76-78	33	0.092	0.744	1.1	29	95	0.10	2,700
126		78-81	33	0.081	0.773	1.2	23	100	0.067	1,600
127		81-86	34	0.368	0.869	0.80	14	56	0.070	1,100

Table A2.1.4.1-1 (Continued)

LAB NO.	Station	Sample Depth, ft MLLW	Meas. Length (inches)	Fraction Retained on #200 Sieve	Fraction Dry Solids	Cadmium (Cd) mg/kg	Lead (Pb) mg/kg	Zinc (Zn) mg/kg	Mercury (Hg) mg/kg	Oil & Grease (Soxhlet extr. method) mg/kg
128		86-91	--	-----	-----	----	--	---	----	----
129	22	52-54	13	0.563	0.700	0.81	17	64	0.95	1,000
130		54-57	16	0.361	0.735	0.54	9.2	58	0.24	510
131		57-59	25	0.198	0.091	0.87	18	81	0.22	450
132[a]		59-62	23	0.131	0.757	0.57	12	84	0.23	250
133		62-67	36	0.265	0.741	0.77	12	72	0.15	360
134		67-72	36	0.394	0.734	0.86	12	68	0.25	420
135[a]		72-82	42	0.170	0.713	1.0	14	96	0.30	390
136		82-85	--	-----	-----	---	--	--	----	---
137	24	52-54	24	0.128	0.597	0.42	49	130	0.22	450
138		54-57	34	0.412	0.784	0.12	22	58	0.10	470
139		57-59	34	0.185	0.716	0.11	21	77	0.20	650
140[a]		59-62	28	0.141	0.742	0.35	76[c]	86	0.10	530

Table A2.1.4.1-1 (Continued)

LAB NO.	Station	Sample Depth, ft MLLW	Meas. Length (inches)	Fraction Retained on #200 Sieve	Fraction Dry Solids	Cadmium (Cd) mg/kg	Lead (Pb) mg/kg	Zinc (Zn) mg/kg	Mercury (Hg) mg/kg	Oil & Grease (Soxhlet extr. method) mg/kg
141		62-67	36	0.300	0.769	0.04	15	58	0.069	1,100
142		67-72	36	0.344	0.770	0.17	12	59	0.093	1,100
143		79-83	36	0.559	0.846	0.27	7.7	48	0.037	430
144		83-85	24	0.802	0.881	0.28	7.2	23	0.031	1,400
145	25	55-57	29	0.104	0.624	0.93	28	130	0.77	980
146		57-60	8	0.253	0.744	0.46	10	77	0.98	330
147		60-62	10	0.275	0.740	0.46	11	75	0.36	300
148		62-65	16	0.297	0.673	0.58	26	64	0.23	420
149		65-70	27	0.032	0.714	0.64	22	84	0.42	450
150		70-75	41	0.174	0.693	0.79	15	76	0.33	550
151		75-80	27	0.178	0.784	0.62	11	74	0.22	690
152		80-85	--	-----	-----	---	--	---	----	----
153	26	61-63	24	0.507	0.735	0.43	7.6	39	0.053	250
154		63-66	32	0.239	0.732	0.51	12	64	0.089	1,200
155		66-68	35	0.115	0.740	0.51	9.1	58	0.094	1,900

Table A2.1.4.1-1 (Continued)

LAB NO.	Station	Sample Depth, ft MLLW	Meas. Length (inches)	Fraction Retained on #200 Sieve	Fraction Dry Solids	Cadmium (Cd) mg/kg	Lead (Pb) mg/kg	Zinc (Zn) mg/kg	Mercury (Hg) mg/kg	Oil & Grease (Soxhlet extr. method) mg/kg
156		68-71	29	0.128	0.740	0.47	9.2	62	0.094	280
157		71-76	35	0.019	0.738	0.65	13	74	0.14	1,400
158		76-81	36	0.459	0.880	0.031	6.9	41	0.063	60
159		81-85	--	-----	-----	---	--	---	----	----
160	27	69-71	16	0.020	0.500	1.3	53	150	0.44	2,100[b]
161		71-74	25	0.145	0.676	0.62	30	72	0.21	<20
162		74-76	35	0.095	0.721	0.79	7.7	110	0.26	430
163		76-79	32	0.175	0.764	0.96	16	77	0.063	1,200
164		79-84	36	0.212	0.775	0.96	15	64	0.031	1,200
165		84-88	42	0.115	0.752	0.84	2.3	110	0.097	433
166[a]	30	49-51	24	0.067	0.569	0.50	50	140	0.26	1,610
167		51-54	34	0.157	0.677	0.24	43	84	0.27	330
168		54-56	34	0.474	0.771	0.12	18	34	0.11	260
169		56-59	30	0.457	0.781	0.93	8.4	46	0.025	60

Table A2.1.4.1-1 (Continued)

LAB NO.	Station	Sample Depth, ft MLLW	Meas. Length (inches)	Fraction Retained on #200 Sieve	Fraction Dry Solids	Cadmium (Cd) mg/kg	Lead (Pb) mg/kg	Zinc (Zn) mg/kg	Mercury (Hg) mg/kg	Oil & Grease (Soxhlet extr. method) mg/kg
170		59-64	36	0.019	0.675	0.096	21	83	0.13	210
171		64-69	31	0.010	0.667	0.29	23	89	0.098	97
172		76-79	31	0.128	0.639	0.05	13	65	0.072	330
173		84-86	26	0.359	0.813	0.03	11.6	50	0.093	16
174	40	36-38	24	0.525	0.755	<0.03	15	33	0.055	39
175[a]		38-41	34	0.691	0.839	0.097	10	41	0.037	69
176		41-44	34	0.484	0.796	0.09	9.7	40	0.047	98
177		44-46	30	0.031	0.683	0.31	15	49	0.221	220
178[a]		46-51	36	0.279	0.747	0.84	15	52	0.043	1,371
179		51-56	--	-----	-----	---	--	---	----	----
180		56-66	21	0.384	0.757	0.99	10	36	0.0092	1,100
181		66-76	23	0.517	0.802	0.83	12	52	0.097	1,900
182	41	47-48	24	0.034	0.614	1.6	39	130	0.17	2,300[b]
183		48-51	34	0.070	0.637	1.6	41	120	0.21	1,800
184		51-54	34	0.325	0.737	0.99	23	46	0.033	1,900

Table A2.1.4.1-1 (Continued)

LAB NO.	Station	Sample Depth, ft MLLW	Meas. Length (inches)	Fraction Retained on #200 Sieve	Fraction Dry Solids	Cadmium (Cd) mg/kg	Lead (Pb) mg/kg	Zinc (Zn) mg/kg	Mercury (Hg) mg/kg	Oil & Grease (Soxhlet extr. method) mg/kg
185		54-59	30	0.336	0.771	1.2	17	52	0.046	2,000
186		59-64	36	0.231	0.764	1.0	16	74	0.045	2,700[b]
187		64-69	--	-----	-----	---	--	---	----	----
188		71-73	21	0.201	0.758	0.97	18	65	0.071	1,900
189		79-85	20	0.283	0.811	0.92	18	64	0.036	1,400
190	43	62-64	20	0.098	0.549	1.7	40	120	0.20	2,500[b]
191		64-67	28	0.412	0.772	0.86	13	46	0.037	1,500
192		67-70	30	0.125	0.711	1.3	24	82	0.078	3,300[b]
193		70-72	32	0.012	0.718	1.4	22	94	0.090	1,300
194		72-77	36	0.102	0.728	1.0	16	82	0.12	700
195		77-82	36	0.050	0.721	1.3	29	100	0.090	1,300
196		82-86	48	0.484	0.743	0.06	5.0	76	0.11	6,200[b,c]
197	44	55-57	24	0.394	0.737	0.21	10.1	34	0.050	400
198		57-60	33	0.414	0.745	0.62	29	37	0.016	1,400

Table A2.1.4.1-1 (Continued)

LAB NO.	Station	Sample Depth, ft MLLW	Meas. Length (inches)	Fraction Retained on #200 Sieve	Fraction Dry Solids	Cadmium (Cd) mg/kg	Lead (Pb) mg/kg	Zinc (Zn) mg/kg	Mercury (Hg) mg/kg	Oil & Grease (Soxhlet extr. method) mg/kg
199		60-62	33	0.116	0.731	1.0	15	78	0.080	1,000
200		62-65	33	0.115	0.764	0.65	18	82	0.031	750
201		65-70	36	0.031	0.735	1.4	18	100	0.088	1,000
202		70-75	24	0.152	0.743	1.2	26	76	0.11	900
203		75-85	--	-----	-----	---	--	---	----	----
204	45	60-62	24	0.375	0.718	0.61	10.0	48	0.25	420
205		62-65	36	0.538	0.824	0.33	5.4	37	0.17	410
206		65-67	34	0.145	0.768	0.94	14	82	0.033	2,700[b]
207		67-70	8	0.090	0.756	0.31	6.2	94	0.15	780
208		70-75	36	0.332	0.804	0.75	14	68	0.068	1,200
209		75-80	33	0.504	0.818	0.91	16	49	0.038	1,300
210[a]		84-86	18	0.408	0.766	0.12	6.8	69	0.12	110
211	46	59-61	34	0.408	0.738	0.33	15	45	0.28	100
212		61-64	33	0.530	0.794	0.17	8.4	32	0.19	130
213		64-66	24	0.636	0.817	0.62	8.7	37	0.027	880

Table A2.1.4.1-1 (Continued)

LAB NO.	Station	Sample Depth, ft MLLW	Meas. Length (inches)	Fraction Retained on #200 Sieve	Fraction Dry Solids	Cadmium (Cd) mg/kg	Lead (Pb) mg/kg	Zinc (Zn) mg/kg	Mercury (Hg) mg/kg	Oil & Grease (Soxhlet extr. method) mg/kg
214		66-69	33	0.339	0.770	0.76	11	72	0.032	980
215		69-74	24	0.343	0.779	0.35	11	51	0.13	<10
216		74-79	37	.337	0.799	0.20	10	56	0.089	850
217		79-85	--	-----	-----	----	--	--	-----	---
218	47	64-66	24	0.465	0.735	0.49	22	48	0.19	1,100
219		66-69	33	0.425	0.796	0.30	15	45	0.12	1,400
220		69-71	33	0.059	0.750	0.65	18	77	0.12	560
221		71-74	37	0.074	0.736	0.35	21	83	0.11	1,800
222		74-79	37	0.825	0.854	0.19	12	23	0.060	710
223		79-84	36	0.798	0.824	0.22	9.5	40	0.040	990
224	48	66-68	24	0.486	0.751	0.23	15	41	0.066	9,300[b,c]
225		68-71	33	0.654	0.812	0.15	12	34	0.045	1,700
226		71-73	33	0.733	0.836	0.21	8.9	30	0.023	1,100
227		73-76	33	0.162	0.803	0.27	16	72	0.038	990
228		76-81	36	0.143	0.777	0.68	11	63	0.056	1,300

Table A2.1.4.1-1 (Continued)

LAB NO.	Station	Sample Depth, ft MLLW	Meas. Length (inches)	Fraction Retained on #200 Sieve	Fraction Dry Solids	Cadmium (Cd) mg/kg	Lead (Pb) mg/kg	Zinc (Zn) mg/kg	Mercury (Hg) mg/kg	Oil & Grease (Soxhlet extr. method) mg/kg
229		81-86	36	0.745	0.815	0.12	5.4	25	0.029	500
230	49	74-76	24	0.613	0.739	0.95	17	38	0.066	1,500
231		76-79	33	0.545	0.774	1.1	14	60	0.026	2,500[b]
232		79-81	34	0.357	0.803	0.17	13	52	0.077	1,100
233		81-84	27	0.224	0.789	0.20	16	60	0.21	1,300
234		84-85	11	0.028	0.708	0.94	13	110	0.19	2,400[b]
235		85-90	--	-----	-----	---	--	---	----	----
236	50	78-80	24	0.685	0.771	0.96	17	32	0.045	1,200
237		80-83	32	0.704	0.780	0.91	8.8	48	0.015	1,200
238[a]		83-86	31	0.625	0.818	0.90	8.6	45	0.019	1,029
239		86-88	22	0.735	0.845	0.58	8.4	32	0.026	1,700
240		88-91	--	-----	-----	---	--	---	-----	----
241	51	84-86	24	0.734	0.790	0.95	19	26	0.025	1,600
242		86-87	12	0.627	0.796	0.93	16	37	0.016	1,100

Table A2.1.4.1-2

Water Depth at Sediment Core Sampling Stations

Station Number	Measured Depth, ft MLLW[a]	Station Number	Measured Depth, ft MLLW	Station Number	Measured Depth, ft MLLW
1	56	15	36	30	49
2	57	16	36	40	36
3	57	17	40	41	47
4	54	17	45	43	52
5	59	18	52	44	55
6	46	20	70	45	60
7	47	21	71	46	59
8	38	22	52	47	64
9	65	24	52	48	66
11	31	25	55	49	74
12	49	26	61	50	78
13	47	27	69	51	84
14	56				

Source: Long Beach Harbor Consultants, 1976.

[a] Mean lower low water.

Table A2.1.4.1-3

Sediment Chemistry Results of Grab Samples

Lab Number	Station Number	Fraction Retained on #200 Sieve	Fraction Dry Solids	Cadminum mg/kg dry wt	Lead mg/kg dry wt	Zinc mg/kg dry wt	Mercury mg/kg dry wt	Oil and Grease mg/kg dry wt
2308	52	0.25	0.717	0.77	19	88	0.43	300
2309	53	0.066	0.581	1.4	36	130	0.66	660
2310	55	0.015	0.501	1.8	42	160	0.56	780
2311	60	0.13	0.612	1.3	30	110	0.60	990
2312	61	0.070	0.531	2.9[a]	140[a]	170[a]	0.43	1,500
2313	62	0.067	0.475	3.4[a]	540[a]	300[a]	0.49	8,000[a]

Source: Long Beach Harbor Consultants, 1976

[a] Exceed proposed Environmental Protection Agency (EPA) Region IX concentration limits.

Table A2.1.4.1-4

Statistical Analyses of Replicate Core Samples

LAB NO.	Replicate Number	Cadmium (Cd) mg/kg	Lead (Pb) mg/kg	Zinc (Zn) mg/kg	Mercury (Hg) mg/kg	Oil & Grease[a] (Sox. extr.) mg/kg
1	1	1.73	59.5	236	1.12	2,610
	2	1.72	62.5	268	1.27	2,500
	3	1.58	54.0	238	1.11	2,470
	4	1.60	51	233	1.04	2,320
	5	1.61	58	234	1.47	2,470
	6	1.70	54	240	1.10	2,940
	7	1.76	64	231	1.35	2,200
		1.67 ± 0.07	57.6 ± 4.8	240 ± 13	1.21 ± 0.16	2,500 ± 230
18	1	0.94	10.1	68	0.22	157
	2	0.88	12.0	79.0	0.16	254
	3	1.08	14.0	68.2	0.22	85
	4	0.81	11.2	62.7	0.25	189
	5	0.86	8.2	67.7	0.25	193
	6	1.52	15.1	87.9	0.14	212
	7	1.09	12.6	85.6	0.29	78
		1.02 ± 0.24	11.9 ± 2.3	74.2 ± 9.9	0.22 ± 0.05	167 ± 65
97	1	0.86	13	60	0.084	800
	2	0.86	13	60	0.082	800
	3	0.85	14	56	0.079	700

Source: Long Beach Harbor Consultants, 1976.

[a] Soxhlet extraction method.

Table A2.1.4.1-4 (continued)

LAB NO.	Replicate Number	Cadmium (Cd) mg/kg	Lead (Pb) mg/kg	Zinc (Zn) mg/kg	Mercury (Hg) mg/kg	Oil & Grease (Sox. extr.) mg/kg
	4	0.87	12	58	0.078	1,100
	5	0.83	12	61	0.097	900
	6	0.88	12	59	0.082	900
	7	0.90	15	60	0.12	700
		0.863 ± 0.0229	13.0 ± 1.2	59.1 ± 1.7	0.0889 ± 0.0151	843 ± 140
132	1	0.51	13.4	85.6	0.19	161
	2	0.69	14.7	91.2	0.15	369
	3	0.51	11.9	82.1	0.23	216
	4	0.60	11.4	85.0	0.28	202
	5	0.66	9.2	80.4	0.41	246
	6	0.46	9.3	82.7	0.20	368
	7	0.55	11.1	78.6	0.15	210
		0.568 ± 0.085	11.6 ± 2.0	83.7 ± 4.1	0.230 ± 0.091	253 ± 83
135	1	1.20	17.2	93.5	0.36	147
	2	1.20	19.0	99.6	0.26	408
	3	0.80	13.6	94.6	0.30	466
	4	0.76	11.8	98.4	0.38	622
	5	0.89	10.6	97.3	0.17	450
	6	1.05	14.3	92.5	0.32	278
	7	1.08	10.7	94.6	0.33	340
		0.997 ± 0.182	13.9 ± 3.2	95.8 ± 2.7	0.303 ± 0.070	378 ± 151
140	1	0.18	17.9	78.0	0.091	464
	2	0.27	18.5	77.9	0.079	810
	3	0.29	12.1	88.0	0.100	308
	4	0.54	13.4	90.1	0.110	459
	5	0.41	12.6	94.6	.145	643
	6	0.39	18.5	85.9	0.095	613
	7	0.04	17.8	90.5	0.086	380
		0.346 ± 0.116	15.8 ± 3.0	86.4 ± 6.4	0.101 ± 0.022	525 ± 173

Table A2.1.4.1-4 (continued)

LAB NO.	Replicate Number	Cadmium (Cd) mg/kg	Lead (Pb) mg/kg	Zinc (Zn) mg/kg	Mercury (Hg) mg/kg	Oil & Grease (Sox. extr.) mg/kg
166	1	0.37	47.6	123	0.259	1,220
	2	0.42	49.7	120	0.249	1,840
	3	0.73	44.6	148	0.253	1,905
	4	0.54	46.0	136	0.273	1,822
	5	0.32	45.6	132	0.252	1,227
	6	0.45	73.0	156	0.304	1,597
	7	0.[illegible]6	41.3	153	0.220	1,670
		0.499 ± 0.152	49.7 ± 10.6	138 ± 14	0.259 ± 0.026	1,610 ± 290
	1	0.095	11.6	26.2	0.034	67.4
	2	0.072	10.2	27.5	0.059	68.2
	3	0.070	10.0	44.6	0.044	70.2
	4	0.19	10.2	42.6	0.051	62.5
	5	0.044	9.1	42.4	0.029	63.5
	6	0.080	8.0	55.8	0.024	76.5
	7	0.130	12.2	46.2	0.019	72.5
		0.097 ± 0.049	10.2 ± 1.4	40.8 ± 10.5	0.037 ± .015	68.7 ± 4.9
	1	0.65	14	52	0.062	1,500
	2	0.99	14	53	0.045	1,600
	3	1.0	14	53	0.040	1,400
	4	0.83	14	53	0.040	1,100
	5	0.77	19	50	0.044	1,200
	6	0.76	13	50	0.064	1,500
	7	0. 06	16	52	0.040	1,300
		0.837 ± 0.127	14.9 ± 2.0	51.9 ± 1.3	0.0479 ± 0.0106	1,371 ± 180
210	1	0.15	6.7	68.5	0.15	94.5
	2	0.18	7.7	64.2	0.15	64.5
	3	0.07	9.8	82.0	0.14	137
	4	0.10	6.5	69.1	0.12	101
	5	0.16	3.5	69.3	0.093	80.0
	6	0.10	7.5	63.4	0.078	80.0
	7	0.06	5.9	67.1	0.090	210
		0.117 ± 0.046	6.80 ± 1.92	69.1 ± 6.2	0.117 ± 0.030	110 ± 50

Table A2.1.4.1-4 (continued)

LAB NO.	Replicate Number	Cadmium (Cd) mg/kg	Lead (Pb) mg/kg	Zinc (Zn) mg/kg	Mercury (Hg) mg/kg	Oil & Grease (Sox. extr.) mg/kg
238	1	0.92	8.9	46	0.017	1,200
	2	0.90	8.4	45	0.017	1,300
	3	0.91	8.5	45	0.022	1,000
	4	0.90	9.0	45	0.018	900
	5	0.90	8.4	45	0.021	1,100
	6	0.89	8.9	41	0.017	1,000
	7	C.91	7.9	45	0.019	700
		0.904 ± 0.0098	8.57 ± 0.39	44.6 ± 1.6	0.0187 ± 0.0021	1,029 ± 198

Table A2.1.4.1-5

Quarterly Measurements of Sediment Quality[a] Within Long Beach Harbor in 1974

STATION RW-1, SEDIMENTS, 1974		Feb 11	May 17	Aug 21	Nov 7
Biochemical oxygen demand		780	660	2,700	1,900
Chemical oxygen demand		22,000	27,000	12,000	22,000
Cyanide		0.23	0.08	0.038	0.055
Phenols		0.1	0.074	0.34	0.16
Total sulfide		170	430	47	110
Oil and grease		1,900	1,100	600	1,800
Chlorinated hydrocarbons,	DDE	0.20	0.03	n.d.	0.064
	DDD	n.d.	n.d.	n.d.	0.007
	DDT	n.d.	n.d.	n.d.	n.d.
Polychlorinated biphenols,	1242	n.d.	n.d.	n.d.	n.d.
	1248	n.d.	n.d.	n.d.	n.d.
	1254	0.20	0.09	n.d.	n.d.
	1262	0.15	n.d.	n.d.	n.d.
Arsenic		3.0	5.5	2.7	0.50
Cadmium		0.53	0.60	1.2	2.4
Total chromium		26	36	45	62
Copper		34	68	34	56
Lead		35	38	28	59
Mercury		0.17	0.28	0.36	0.020
Nickel		9.1	36	28	41
Silver		1.4	1.2	1.7	2.3
Zinc		76	112	110	140
Total coliform bacteria					
MPN/g, wet wt basis		730	0.2	3.6	0.3
MPN/g, dry wt basis		1300	0.3	5.0	0.5
Fecal coliform bacteria					
MPN/g, wet wt basis		330	0.2	0.1	0.1
MPN/g, dry wt basis		540	0.3	0.2	0.2
Biochemical oxygen demand		910	500	3,300	2,300
Chemical oxygen demand		55,000	24,000	29,000	30,000
Cyanide		0.53	0.12	0.29	0.073
Phenols		0.1	0.035	0.044	0.15
Total sulfide		760	440	190	150
Oil and grease		3,100	810	650	2,800
Chlorinated hydrocarbons,	DDE	0.15	0.05	n.d.	0.050
	DDD	n.d.	n.d.	n.d.	0.009
	DDT	n.d.	n.d.	n.d.	n.d.
Polychlorinated biphenols,	1242	n.d.	n.d.	n.d.	n.d.
	1248	n.d.	n.d.	n.d.	n.d.
	1254	0.10	0.10	n.d.	n.d.
	1262	0.15	n.d.	n.d.	n.d.
Arsenic		15	2.3	7.5	13
Cadmium		1.2	1.4	2.4	1.9

Source: Southern California Edison Company Marine Monitoring Studies, 1974.

[a] mg/kg, dry-weight basis:

Total chromium	50	24	93	64
Copper	83	25	95	83
Lead	75	33	97	63
Mercury	0.67	0.37	0.82	0.052
Nickel	16	21	49	46
Silver	1.4	0.90	7.7	1.7
Zinc	180	78	250	200

Table A2.1.4.1-5 (continued)

STATION RW-3, SEDIMENTS, 1974		Feb 11	May 17	Aug 21	Nov 7
Total coliform bacteria					
MPN/g, wet wt basis		22,000	0.2	3.7	14
MPN/g, dry wt basis		40,000	0.3	6.6	26
Fecal coliform bacteria					
MPN/g, wet wt basis		4,900	0.2	0.1	14
MPN/g, dry wt basis		9,000	0.3	0.2	26
Biochemical oxygen demand		2,000	1,600	4,400	3,000
Chemical oxygen demand		100,000	57,000	36,000	54,000
Cyanide		0.01	0.020	0.017	0.065
Phenols		0.1	0.034	0.24	0.22
Total sulfide		1,600	4,100	290	220
Oil and grease		8,300	5,200	940	5,400
Chlorinated hydrocarbons,	DDE	0.35	0.28	n.d.	0.17
	DDD	n.d.	n.d.	n.d.	0.016
	DDT	n.d.	n.d.	n.d.	n.d.
Polychlorinated biphenols,	1242	n.d.	n.d.	n.d.	n.d.
	1248	n.d.	0.22	n.d.	n.d.
	1254	0.25	0.43	n.d.	n.d.
	1262	0.10	n.d.	n.d.	n.d.
Arsenic		4.7	12	12	14
Cadmium		2.3	2.0	3.4	3.3
Total chromium		110	110	100	120
Copper		140	130	110	130
Lead		110	110	71	62
Mercury		1.5	1.8	2.2	0.076
Nickel		22	56	50	67
Silver		1.7	1.5	4.1	2.5
Zinc		320	840	410	380
Total coliform bacteria					
MPN/g, wet wt basis		160,000	0.8	16	1.8
MPN/g, dry wt basis		370,000	1.5	30	3.1
Fecal coliform bacteria					
MPN/g, wet wt basis		13,000	0.8	0.1	0.3
MPN/g, dry wt basis		30,000	1.5	0.3	0.5
Biochemical oxygen demand		1,400	720	2,900	1,700
Chemical oxygen demand		62,000	49,000	20,000	41,000
Cyanide		0.13	0.09	0.10	0.055
Phenols		0.1	0.034	0.19	0.17
Total sulfide		140	1,000	100	90
Oil and grease		2,200	2,100	490	1,300
Chlorinated hydrocarbons,	DDE	0.15	0.07	0.019	0.069
	DDD	n.d.	n.d.	n.d.	0.013
	DDT	n.d.	n.d.	n.d.	n.d.
Polychlorinated biphenols	1242	n.d.	n.d.	n.d.	n.d.
	1248	n.d.	n.d.	n.d.	n.d.
	1254	0.10	0.13	n.d.	n.d.
	1262	n.d.	n.d.	n.d.	n.d.
Arsenic		5.7	10	5.9	12
Cadmium		2.2	1.3	2.0	3.1
Total chromium		18	49	36	87
Copper		41	68	59	73
Lead		78	65	35	69
Mercury		0.42	0.59	1.3	0.048
Nickel		11	45	32	45
Silver		3.9	0.85	4.7	2.5
Zinc		93	220	170	190

Table A2.1.4.1-5 (continued)

STATION RW-3, SEDIMENTS, 1974	Feb 11	May 17	Aug 21	Nov 7
Total coliform bacteria				
MPN/g, wet wt basis	1,400	0.2	12	2.0
MPN/g, dry wt basis	2,400	0.3	18	4.0
Fecal coliform bacteria				
MPN/g, wet wt basis	1,100	0.2	0.1	0.1
MPN/g, dry wt basis	1,900	0.3	0.2	0.2
Biochemical oxygen demand	520	560	3,200	1,600
Chemical oxygen demand	45,000	35,000	41,000	46,000
Cyanide	0.52	0.07	0.10	0.13
Phenols	0.1	0.087	0.021	0.12
Total sulfide	60	190	72	82
Oil and grease	2,100	1,400	810	3,400
Chlorinated hydrocarbons, DDE	0.20	0.14	0.17	0.080
DDD	n.d.	n.d.	0.084	n.d.
DDT	n.d.	n.d.	0.067	0.19
Polychlorinated biphenols, 1242	n.d.	n.d.	n.d.	n.d.
1248	n.d.	0.06	n.d.	n.d.
1254	0.15	n.d.	n.d.	n.d.
1262	n.d.	n.d.	n.d.	n.d.
Arsonic	8.5	9.8	15	3.9
Cadmium	0.84	1.3	2.6	2.3
Total chromium	49	48	120	100
Copper	77	260	130	120
Lead	59	69	83	83
Mercury	3.6	1.2	3.0	0.045
Nickel	11	28	57	64
Silver	1.7	0.87	0.90	1.1
Zinc	160	190	290	290
Total coliform bacteria				
MPN/g, wet wt basis	1,700	0.2	190	0.3
MPN/g, dry wt basis	3,000	0.3	390	0.6
Fecal coliform bacteria				
MPN/g, wet wt basis	1,300	0.2	0.1	0.3
MPN/g, dry wt basis	2,300	0.3	0.3	0.6
Biochemical oxygen demand	670	620	3,400	1,300
Chemical oxygen demand	83,000	45,000	46,000	47,000
Cyanide	0.65	0.090	0.070	0.067
Phenols	0.1	0.095	0.23	0.14
Total sulfide	220	1,100	540	38
Oil and grease	4,000	2,900	720	2,400
Chlorinated hydrocarbons, DDE	0.20	0.14	0.12	0.042
DDD	n.d.	n.d.	0.097	0.010
DDT	n.d.	n.d.	0.05	0.021
Polychlorinated biphenols, 1242	n.d.	n.d.	n.d.	n.d.
1248	n.d.	0.16	n.d.	n.d.
1254	0.10	0.37	n.d.	n.d.
1262	n.d.	0.19	n.d.	n.d.
Arsenic	17	10	3.2	11
Cadmium	2.0	2.0	4.0	2.4
Total chromium	66	72	91	78
Copper	100	100	120	100
Lead	81	90	56	66
Mercury	1.4	1.6	1.6	0.11
Nickel	19	48	54	61
Silver	3.2	3.0	1.4	1.9
Zinc	320	510	300	270

Table A2.1.4.1-5 (continued)

STATION RW-3, SEDIMENTS, 1974	Feb 11	May 17	Aug 21	Nov 7
Total coliform bacteria				
MPN/g, wet wt basis	11,000	0.8	8.1	0.3
MPN/g, dry wt basis	28,000	1.5	17	0.7
Fecal coliform bacteria				
MPN/g, wet wt basis	3,300	0.8	0.1	0.1
MPN/g, dry wt basis	8,500	1.5	0.3	0.3

Table A2.1.4.1-6

Characteristics of Grain Size Distribution Curves at Benthic Stations

STATION	I. Sand Population[a] Percent of Distribution	FT[b] (phi)	II. Clay Population[a] Percent of Distribution	Composite Distribution Parameters: Median Diameter[c] (mm)	Sorting Coefficient[c] (phi)	Skewness[c] (phi)
			Group A			
1	25 ±5	4.2	75 ±5	0.012	3.01	0.14
3	15 ±20	4.2 6.2	85 ±15	0.012	2.45	0.32
6	35 ±5	4.7	65 ±5	0.018	2.55	0.27
7	35 ±5	4.5	65 ±5	0.016	3.06	0.19
8	30 ±5	5.0	70 ±5	0.014	2.75	0.31
62	35 ±5	4.6	65 ±5	0.014	-	-
55	25 ±5	5.5	75 ±5	0.0069	-	-
27	20 ±5	4.9	80 ±5	0.0090	-	-
61	25 ±5	4.9	75 ±5	0.0096	-	-
19	20 ±5	4.9	75 ±5	0.0087	-	-
56	35 ±5	4.9	65 ±5	0.012	-	-
$\bar{X}$	27	4.8	73	0.012	2.74	0.25
S.D.	±7	±0.3	±7	±0.003	±0.30	±0.08
			Group B			
11	60±	4.6	40±5	0.054	2.10	0.71
13	45±5	4.5	55±5	0.025	2.65	0.47
25	38±5	4.6	62±5	0.021	-	-
59	55±5	4.4	45±5	0.053	2.90	0.69
60	40±5	4.6	60±5	0.024	3.02	0.47
9	45±6	4.9	55±5	0.023	2.38	0.27
52	60±5	4.6	40±5	0.036	2.78	0.62
$\bar{X}$	49	4.6	51	0.034	2.63	0.54
S.D.	±9	0.2	±9	±0.22	±0.15	±0.14
			Group C			
44	75±5	4.3	25±5	0.069	1.38	0.5
46	85±5	4.3	15±5	0.067	0.49	0.1
30	75±5	5.0	25±5	0.041	1.62	0.4
53	70±5	4.4	30±5	0.062	1.75	0.60
$\bar{X}$	76	4.5	24	0.060	1.31	0.37
S.D.	±6	0.33	±6	±0.013	±0.57	±0.34

Source: Long Beach Harbor Consultants, 1976.

[a] Spencer Classification (1963).

[b] Fine truncation point.

[c] Inman's parameters (1952).

Table A2.1.4.1-6 (Continued)

STATION	I. Sand Population Percent of Distribution	FT (phi)	II. Clay Population Percent of Distribution	Composite Distribution Parameters: Median Diameter (mm)	Sorting Coefficient (phi)	Skewness (phi)
			Group D			
49	96±2	4.6	4±2	0.145	0.78	0.28
51	96±2	4.2	4±2	0.100	0.50	0.04
58	96±2	4.2	4±2	0.120	0.72	0.03
$\overline{X}$	96	4.3	4	0.122	0.67	0.12
S.D.	±0	0.2	±0	±0.22	±0.15	±0.14

Table A 2.1.4.1-7

Comparison of Surface Samples

in Long Beach Harbor and Vicinity (ppm)

STATION	Cadmium	Lead	Zinc	Mercury	Oil, Grease
Proposed EPA criteria:[a]					
Unpolluted	2.3	75	190	1.2	1,900
Polluted	3.2	110	250	1.7	2,800
A[b] -1	1.7	58	240	1.2	2,500
B[c] -RW12	1.8	74	232	2.6	1,928
C[d] -B7	2.24	47.9	135	0.60	1,320
A-6	7.8	18	110	0.26	740
B-7H(RW4)	2.8	88	488	1.8	4,960
C-B6	3.15	140	399	1.64	1,710
A-5	1.0	14	97	0.23	660
B-RW4	2.75	81	488	1.4	4,960
A-3	1.4	89	260	2.6	2,800
B-RW13	2.6	73	350	1.6	2,505
C-B5	2.24	92	133	0.80	1,410
A-9	0.81	20	93	0.30	1,300
B-RW1	1.8	40	110	0.38	1,350
C-B4	2.77	72.1	147	0.49	1,130
A-12	0.45	11	60	0.21	180
C-B8	2.14	56.1	97.6	0.16	1,090
A-20	1.8	64	180	0.32	2,500
C-B3	2.79	104	178	0.36	1,780

[a] Dredge material disposal criteria, Environmental Protection Agency, Revision 2.

[b] A -- Data from Long Beach survey, September -- December 1975, core samples.

[c] B -- Data from Quarterly Surveys by EQA/MBC for Southern California Edison, 1974 -- mean values.

[d] C -- Allan Hancock Foundation 1973-1975 data. The 1975 data was used rather than 1973 when both were provided.

Table A 2.1.4.1-7 (Continued)

STATION	Cadmium	Lead	Zinc	Mercury	Oil & Grease
A-53	--[e]	--	--	--	--
C-B9	3.10	85.3	146	0.43	1,420
D-53[f]	1.4	36	130	0.66	660
A-55	--	--	--	--	--
C-B10	2.05	111	177	0.46	1,730
D-55	1.8	42	160	0.56	780
A-30	.50	50	140	0.26	1,610
C-B11	2.71	98.6	156	0.38	1,860
A-47	0.49	22	48	0.19	1,100
C-B1	1.98	38.4	61.0	0.11	1,120
A-60	--	--	--	--	--
D-60	1.3	30	110	0.60	990
A-61	--	--	--	--	--
C-D1	2.38	119	159	0.204	1,860
D-61	2.90	140	170	0.43	1,500
A-62	--	--	--	--	--
C-D2	2.26	375	255	0.147	2,100
D-62	3.4	540	300	0.49	8,000

[e] A-53, 55, 60, 61, 62 data were not provided by Port of Long Beach, (core).

[f] D -- Data from Long Beach surface grab samples, September-December 1975.

Table A2.1.4.1-8

Nutrient Levels in Sediments Within Long Beach Harbor[a]

STATION	Organic N	Total N	Total P	Total DDT	Total PCB
B7	545	573	1,830	0.0216	3.717
B6	423	443	1,700	0.0195	3.32
B5	1,410	195	218	0.0180	0.504
B3	1,780	411	424	0.01834	1.743
B2	1,670	242	258	0.01098	1.521

Source: Allan Hancock Foundation, 1973-1975.

[a] Measured in parts per million (ppm).

REFERENCES

Appendix-2.1.4.1

1. Allan Hancock Foundation. 1975. Report to the U.S. Army Corps of Engineers on Environmental Investigations and Analyses. Los Angeles Harbor 1973-1975. Allan Hancock Foundation, University Southern California, Los Angeles, Calif.

2. Long Beach Harbor Consultants (Jack K. Bryant and Associates, Inc.; Environmental Quality Analysts; Marine Biological Consultants, Inc.; Converse Davis Dixon Associates). 1976. Environmental and Geotechnical Sampling Program. Program. Vols. 1 and 2. The Port of Long Beach, Long Beach, Calif.

3. Southern California Edison Company. 1974. Marine Monitoring Studies, Vol. 1 Long Beach Generating Station. Prepared by Environmental Quality Analysts and Marine Biological Consultants for Southern California Edison Company.

APPENDIX A2.1.5.2

Water Resource Tables

Table A2.1.5.2-1

Surface Water Features Encountered in California by the Proposed Project

RIVER, CREEK, WASH, OR CANAL	Approximate Location Section	Township	Range
Long Beach to Beaumont (Totally New Construction)			
Los Angeles River		T. 5 S. & T. 3 S.	
Rio Hondo		T. 2 S.	
Whittier Narrows (San Gabriel River)		T. 2 S.	
San Jose Creek		T. 2 S.	
South San Jose Creek (+1 Drain)		T. 2 S.	
Chino Creek (+3 Drains)		T. 2 S.	
Cypruss Channel		T. 2 S.	
Cucamonga Channel		T. 2 S.	
San Sevaine Channel		T. 2 S.	
West Riverside Canal		T. 2 S.	
Rialto Channel		T. 2 S.	
Santa Ana River		T. 1 S.	
Reche Canyon Channel		T. 1 S.	
Gage Canal		T. 1 S.	
Loma Linda Drain		T. 1 S.	
San Timoteo Creek and associated drainages		T. 1 S. & T. 2 S.	
Beaumont to Desert Center (Conversion of Existing Facilities)			
San Timoteo drainages			
Wash	Sec. 35	T. 2 S.	R. 2 W.
Wash	Sec. 1	T. 3 S.	R. 2 W.
Wash	Sec. 31	T. 2 S.	R. 1 W.
Wash	Sec. 6	T. 3 S.	R. 1 W.
Little San Gorgonio Creek	Sec. 5	T. 3 S.	R. 1 W.
Noble Creek	Sec. 4	T. 3 S.	R. 1 W.
Wash	Sec. 3	T. 3 S.	R. 1 W.
Potrero Creek	Sec. 2	T. 3 S.	R. 1 W.
Smith Creek and drainages	Sec. 1	T. 3 S.	R. 1 W.
Montgomery Creek	Sec. 6	T. 3 S.	R. 1 E.
Wash	Sec. 9	T. 3 S.	R. 1 E.
Wash	Sec. 9	T. 3 S.	R. 1 E.
Wash	Sec. 11	T. 3 S.	R. 1 E.
Wash	Sec. 12	T. 3 S.	R. 1 E.
San Gorgonio River and drainages	Secs. 12	T. 3 S.	R. 1 E.
Wash	Sec. 12	T. 3 S.	R. 1 E.
4 Washes	Sec. 9	T. 3 S.	R. 2 E.
2 Washes	Sec. 10	T. 3 S.	R. 2 E.
Wash	Sec. 11	T. 3 S.	R. 2 E.
Wash	Sec. 12	T. 3 S.	R. 3 E.
Stubbe Canyon Wash	Sec. 8	T. 3 S.	R. 3 E.
Cottonwood Canyon Wash	Sec. 9	T. 3 S.	R. 3 E.

RIVER, CREEK, WASH, OR CANAL	Approximate Location Section	Township	Range
Beaumont to Desert Center (Continued) (Conversion of Existing Facilities)			
Whitewater River and drainages	Secs. 14 & 13	T. 3 S.	R. 3 E.
Garnet Wash	Sec. 22	T. 3 S.	R. 4 E.
Mission Creek	Sec. 24	T. 3 S.	R. 4 E.
West Branch of Salvia Wash	Sec. 30	T. 3 S.	R. 5 E.
Morongo Wash (2)	Secs. 30 & 29	T. 3 S.	R. 5 E.
Indio Hills and Little San Bernardino drainages			
1 Wash	Sec. 17	T. 5 S.	R. 8 E.
1 Wash	Sec. 15	T. 5 S.	R. 8 E.
1 Wash	Sec. 22	T. 5 S.	R. 8 E.
2 Washes	Sec. 23	T. 5 S.	R. 8 E.
2 Washes	Sec. 24	T. 5 S.	R. 8 E.
1 Wash (West Double Canyon)	Sec. 30	T. 5 S.	R. 9 E.
1 Wash (East Double Canyon)	Sec. 29	T. 5 S.	R. 9 E.
1 Wash	Sec. 29	T. 5 S.	R. 9 E.
1 Wash (Front Hill Canyon Wash)	Sec. 28	T. 5 S.	R. 9 E.
2 Washes	Sec. 34	T. 5 S.	R. 9 E.
2 Washes	Sec. 35	T. 5 S.	R. 9 E.
1 Wash	Sec. 2	T. 6 S.	R. 9 E.
1 Wash	Sec. 1	T. 6 S.	R. 9 E.
1 Wash (Painted Canyon)	Sec. 5	T. 6 S.	R. 10 E.
Shavers Valley drainages			
2 Washes	Sec. 4	T. 6 S.	R. 10 E.
1 Wash (Pinkham Wash)	Sec. 4	T. 6 S.	R. 10 E.
2 Washes	Sec. 10	T. 6 S.	R. 10 E.
1 Wash	Sec. 12	T. 6 S.	R. 10 E.
1 Wash	Sec. 7	T. 6 S.	R. 11 E.
1 Wash	Sec. 8	T. 6 S.	R. 11 E.
1 Wash	Sec. 9	T. 6 S.	R. 11 E.
1 Wash	Sec. 10	T. 6 S.	R. 11 E.
Hayfield Lake drainages			
1 Wash	Sec. 3	T. 6 S.	R. 13 E.
2 Washes	Sec. 2	T. 6 S.	R. 13 E.
1 Wash	Sec. 1	T. 6 S.	R. 13 E.
Chuckwalla Valley drainages			
1 Wash	Sec. 5	T. 6 S.	R. 14 E.
1 Wash	Sec. 32	T. 5 S.	R. 14 E.
2 Washes	Sec. 33	T. 5 S.	R. 14 E.
1 Wash	Sec. 34	T. 5 S.	R. 14 E.
3 Washes	Sec. 35	T. 5 S.	R. 14 E.
1 Wash	Sec. 36	T. 5 S.	R. 14 E.
2 Washes	Sec. 30	T. 5 S.	R. 15 E.
2 Washes	Sec. 29	T. 5 S.	R. 15 E.
2 Washes	Sec. 25	T. 5 S.	R. 15 E.
1 Wash	Sec. 30	T. 5 S.	R. 16 E.
1 Wash	Sec. 29	T. 5 S.	R. 16 E.
1 Wash	Sec. 32	T. 5 S.	R. 16 E.
2 Washes	Sec. 33	T. 5 S.	R. 16 E.
2 Washes	Sec. 34	T. 5 S.	R. 16 E.
1 Wash	Sec. 6	T. 6 S.	R. 17 E.
2 Washes	Sec. 5	T. 6 S.	R. 17 E.

Table A2.1.5.2-1 (Continued)

RIVER, CREEK, WASH, OR CANAL	Approximate Location Section	Township	Range
Beaumont to Desert Center (Continued) (Conversion of Existing Facilities)			
1 Wash	Sec. 8	T. 6 S.	R. 17 E.
1 Wash	Sec. 9	T. 6 S.	R. 17 E.
1 Wash	Sec. 11	T. 6 S.	R. 17 E.
1 Wash	Sec. 17	T. 6 S.	R. 18 E.
Desert Center to Colorado River (Totally New Construction)			
Chuckwalla Valley drainages			
1 Wash	Sec. 25	T. 6 S.	R. 18 E.
1 Wash	Sec. 30	T. 6 S.	R. 18 E.
1 Wash	Sec. 29	T. 6 S.	R. 18 E.
2 Washes	Sec. 35	T. 6 S.	R. 19 E.
1 Wash	Sec. 6	T. 7 S.	R. 20 E.
2 Washes	Sec. 5	T. 7 S.	R. 20 E.
1 Wash (Wiley's Well Wash)	Sec. 3	T. 7 S.	R. 20 E.
Palo Verde Area			
Drain (backwater)	Sec. 18	T. 7 S.	R. 22 E.
Rannals Drain	Sec. 17	T. 7 S.	R. 22 E.
Drain	Sec. 17	T. 7 S.	R. 22 E.
C-03-11 Canal	Sec. 17 & 16	T. 7 S.	R. 22 E.
C-03 Canal	Sec. 16	T. 7 S.	R. 22 E.
WC-6 Canal	Sec. 16	T. 7 S.	R. 22 E.
Canal	Sec. 15	T. 7 S.	R. 22 E.
West Side Drain	Sec. 15	T. 7 S.	R. 22 E.
C-05 Canal	Sec. 13	T. 7 S.	R. 22 E.
Central Drain	Sec. 13	T. 7 S.	R. 22 E.
C Canal	Sec. 18	T. 7 S.	R. 23 E.
Lovekin Drain	Sec. 18	T. 7 S.	R. 23 E.
D Canal	Sec. 16	T. 7 S.	R. 23 E.
D-10-11 Canal	Sec. 23	T. 7 S.	R. 23 E.
D-10-11-2 Canal (Canal F)	Sec. 23	T. 7 S.	R. 23 E.
Colorado River	Sec. 4	T. 2 N.	R. 22 W.

Table A2.1.5.2-2

Surface Water Features Encountered by the Proposed Pipeline Project East of California

RIVER, STREAM, WASH OR CANAL	Approximate Location Section	Township	Range
Arizona			
Ehrenberg Wash	Sec 12	T. 3 N.	R. 22 W.[a]
Tyson Wash	Sec 31	T. 3 N.	R. 19 W.
French Creek	Sec 15	T. 2 N.	R. 18 W.
Alamo Wash	Sec 13	T. 2 N.	R. 16 W.
Centennial Wash	Sec 15	T. 1 N.	R. 9 W.
Centennial Wash	Sec 23	T. 1 S.	R. 7 W.
Gila River	Sec 23	T. 2 S.	R. 5 W.
Waterman Wash	Sec 28	T. 3 S.	R. 1 W.
Vekol Wash	Sec 22	T. 5 S.	R. 2 E.
Santa Rosa Wash	Sec 5	T. 6 S.	R. 4 E.
Santa Cruz Wash	Sec 1	T. 6 S.	R. 4 E.
Florence-Casa Grande Canal	Sec 18	T. 6 S.	R. 9 E.
Brady Wash	Sec 24	T. 6 S.	R. 9 E.
Brady Wash	Sec 29	T. 6 S.	R. 10 E.
Brady Wash	Sec 33	T. 7 S.	R. 12 E.
Tucson Wash	Sec 25	T. 9 S.	R. 15 E.
Peppersauce Wash	Sec 17	T. 10 S.	R. 17 E.
Alden Wash	Sec 1	T. 11 S.	R. 17 E.
San Pedro River	Sec 27	T. 11 S.	R. 18 E.
Hot Springs Canyon Draw	Sec 8	T. 13 S.	R. 22 E.
Gold Gulch	Sec 18	T. 13 S.	R. 27 E.
Buckeye Wash	Sec 24	T. 13 S.	R. 27 E.
San Simon Creek	Sec 13	T. 13 S.	R. 30 E.

[a] Salt River meridian

Table A2.1.5.2-2 (Continued)

	Approximate Location		
RIVER, STREAM, WASH OR CANAL	Section	Township	Range
New Mexico			
Burro Cienaga	Sec 7	T. 23 S.	R. 17 W.[b]
Burro Cienaga	Sec 19	T. 23 S.	R. 14 W.
Ninetysix Creek	Sec 22	T. 23 S.	R. 15 W.
China Draw	Sec 20	T. 23 S.	R. 13 W.
Rio Grande	Sec 5	T. 26 S.	R. 3 E.
Pecos River	Sec 8	T. 26 S.	R. 29 E.
Texas			
Antelope Draw	Sec 9 BLK K Univ Lands Hudspeth Co.		
Eight Mile Draw	Sec 1 BLK L Univ Lands Hudspeth Co.		
Delaware River	Sec 5 BLK 64 T. 2 S. T&P Culberson Co.		
Midland Draw	Sec 12 BLK 40 T. 1 S. T&P Midland Co.		

[b] New Mexico principal meridian

Table A2.1.5.2-3

Streamflow Data for South Coastal Basin, Lower Colorado River and Great Basin

PERIOD AND STREAM GAGING STATION	Drainage Area (sq. mi.)	Average Annual Discharge (CFS)[a]: Average for Period of Record	Average Annual Discharge (CFS)[a]: Maximum Year	Average Annual Discharge (CFS)[a]: Maximum CFS	Average Annual Discharge (CFS)[a]: Minimum Year	Average Annual Discharge (CFS)[a]: Minimum CFS	Daily Discharge Extremes: Maximum Date	Daily Discharge Extremes: Maximum CFS	Daily Discharge Extremes: Minimum Date	Daily Discharge Extremes: Minimum CFS
Los Angeles River Basin										
1961-65 Los Angeles River at Long Beach	832	167	1962	245	1961	44.2	2/12/62	42,200	10/8, 9/61	0.60
1966-69 (Records: Dec/28-Sept/73)			na[b]	na	na	na	na	na	na	na
1970-73			1973	254	1972	107	11/29/70	65,100	4/23, 24/71	17.0
1961-65 Rio Hondo above Whittier	91.2	32.6	1962	50.4	1961	6.01	2/11/62	6,650	12/7/60	0
1966-69 Narrows Dam							1/25/69	17,700		
1970-73 (Records: Feb/56-Sept/73)			1973	33.8	1972	8.71	2/27/72	11,400	1/31/70	.53
San Gabriel River Basin										
1964-65 San Gabriel River above Whittier	353	na	1965	128	1964	72.6	4/9/65	9,460	1964[c]	0
1966-69 Narrows Dam							1/25/69	46,600		
1970-73 (Records: 1955-57; 1963-73)			1973	173	1972	63.8	1/16/73	13,300	7/12; 8/10/71	2.8
1961-65 San Jose Creek near El Monte	87.8	30.7	na	na	na	na	na	na	1964-65[c]	0
1966-69 (Records: Oct/64-Sept/73)							1/24/67	10,200		
1970-73			1973	38.4	1972	17.8	2/13/73	6,440	8/26/72	3.0
Santa Ana River Basin										
1961-65 San Antonio Creek near Claremont	16.5	9.95	1962	3.98	1961	.32	2/11/62	182	8/18-26/64	.10
1966-69 (Records: 1917-Sept/73)										
1970-73			1970	11.1	1972	.92	11/29/70	202	8/15/72	.42
1961-65 Cucamonga Creek near Upland	10.1	8.08	1962	5.21	1964	2.05	11/20/61	280	10/5,6/61	.30
1966-69 (Records: Oct-27-Sept/73)										
1970-73			1973	11.6	1972	3.00	11/29/70	580	11/10/71	.87
1961-65 Day Creek near Etiwanda	4.59	4.09	1962	1.87	1961	.26	12/2/61	174	1961[c]	1.0
1966-69 (Records: Oct/27-Sept/72)	4.56						1/25/69	9,450		
1970-73	(revised)		1970	3.17	1972	2.64	11/29/70	358	9/1/72	1.0
1961-65 Santa Ana River below Prado Dam	1,490	na	1962	55.8	1964	45.7	2/20/62	649	10/1/62	14
1966-69 (Records: May/30-Nov/39;	(revised)									
1970-73 May/40-Sept/73)			1973	106	1972	63.9	3/26/73	575	9/24-30/73	3.0
1961-65 Lytle Creek at Colton	172	6.98					2/11/62	1,520	1961-65[d]	0
1966-69 (Records: Oct/57-Sept/73)										
1970-73			1973	8.34	1970	1.32	2/11/73	4,810	1970-73[d]	0
1961-65 San Timoteo Creek near Redlands	119	1.28					9/18/65	708	1961-65[d]	0
1966-69 (Records: Oct/26-Sept/65)										
1966-69 San Timoteo Creek near Loma Linda							2/25/69	15,000		
1970-73 (Records: Feb/68-Sept/73)	125	2.65	1971	2.05	1972	.91	3/1/70	831	1973[c]	0
Salton Sea Drainage Basin										
1961-65 Whitewater River at White Water	57.4	16.4	1962	6.18	1961	4.27	9/18/63	660	11/19/64	0.20

Source: Adapted from U.S. Geological Survey Water Supply Paper #1927, 1970b, p. 533; Water Supply Paper #1928, 1970c, p. 114; U.S. Geological Survey, California Department of Water Resources, 1970d, p. 154; 1971, p. 172; 1972, p. 150; 1973a, p. 156.

[a] Average discharge represents flow to the ocean regardless of upstream development.

[b] Not available.

[c] Many days.

Table A2.1.5.2-3 (Continued)

PERIOD AND STREAM GAGING STATION	Drainage Area (sq. mi.)	Average Annual Discharge (CFS): Average for Period of Record	Average Annual Discharge (CFS): Maximum Year	Maximum CFS	Minimum Year	Minimum CFS	Daily Discharge Extremes: Maximum Date	Maximum CFS	Minimum Date	Minimum CFS
1966-69 (Records: Oct/48-Sept/73)			1969	119	1968	17.3	1/25/69	4,970	1966[c]	0
1970-73			1970	28.3	1973	9.69	2/28/71	1,000	12/25-29/72	5.5
1961-65 Snow Creek near White Water	10.8	8.40	na	na	na	na	12/2/61	285	6/23-27 & 9/5-11/61	2.1
1966-69 (Records: 1922-26; 1928-31;1959-73)			1969	33	1968	5.88	1/25/69	3,490	9/9, 10/68	2.7
1970-73			1972	9.37	1971	.0040	12/24/71	1,130	9/12-16-72	2.4
1961-65 Deep Creek near Palm Desert	30.6	.56	1964	.051	1963	.002	7/26/64	52	5/9/62	0
1966-69 (Records: May/62-Sept/73)			1966	2.49	1968	.21	11/23/65	342	1966-69[c]	0
1970-73			1970	.37	1972	.010	8/2/73	244	1971-72[d]	0
1961-65 Long Creek near Desert Hot Springs	19.4	.005	na	na	na	na	8/7/63	9,270	1963[d]	0
1966-69 (Records: Apr/63-Sept/73)			1969	.005	1967	.0005	8/20/68	36	1966-69[d]	0
1970-73			1971	.004	1970	.002	10/27/71	38	1970-71[d]	0
Chuckwalla Valley										
1964-65 Corn Springs Wash near Desert Center	24.1	.18	na	na	na	na	8/2/64	600	1965	0
1966-69 (Records: Oct/63-Sept/71)			1969	1.23	1966[e]	0	10/3/68	10,500	1966-69[d]	0
1970-71			1970	.195	1971	.0029	8/21/71	480	1970-71[d]	0
Colorado River Basin										
1964-65 Colorado River below Palo Verde	182,200	9,600	1961	8,299	1965	7,285	7/13/65	15,900	12/21/61	1,380
1966-69 Dam (Records: Mar/56-Sept/73			1969	7,465	1968	7,250	8/9/66	16,400[f]	1/27/69	1,350
1970-73			1971	7,345	1973	6,988	4/8/70	13,200	11/24/62	1,060
1961-65 Palo Verde Canal near Blythe		1,196	1965	1,117	1961	1,321	na	na	na	na
1966-69 (Records: 1950-Sept/73)			1969	1,225	1966	1,118	7/3/66	2,050	1966-69[c]	0
1970-73			1972	1,253	1970	1,176	7/71	2,050	1970-73[c]	0

[d] Most of the year.

[e] Entire year

[f] Result of sluicing operations at Palo Verde Dam.

Table A2.1.5.2-4

Water Quality Data[a] for Los Angeles River at Pacific Coast Highway, Long Beach, California

DATE	Time	Temperature[b] C (Degree)	Turbidity (Degree)	pH Units	Dissolved Oxygen	Alkalinity as $CaCO_3$	Total Solids	Suspended Solids	Dissolved Solids	Oil and Grease	Chloride	Nitrate	Bacteria Coliform (MPN/ml)
11 Mar. 1970	1005	14	heavy	7.8	5.9	197.0	5,729	10	5,719	1.8	4,150	20	500
3 June 1970	0950	19	heavy	7.9	0.3	150.2	22,064	36	22,028	4.6	12,055	13	2,400
2 Sep. 1970	1030	20	moderate	7.3	0.9	165.2	25,422	42	25,380	5.0	15,025	12	6.2
6 Jan. 1971	--	10	slight	7.0	5.0	199.0	14,322	36	14,286	0.8	6,946	20	62,000
3 Mar. 1971	--	10	high	7.3	11.5	180.0	1,166	18	1,148	0.4	418.1	13.4	13,000
2 June 1971	1100	18	heavy	7.8	1.7	192.8	9,243	17	9,226	2.4	4,633.9	0.7	5,000
1 Sep. 1971	1000	20	high	8.2	6.0	192.0	19,207	481	18,726	11.6	10,205	9.0	240
1 Dec. 1971	0950	15	low	7.7	0.6	200.0	18,933	26	18,907	2.2	9,806	13	13,000
1 Mar. 1972	1205	18	slight	7.4	1.8	217.6	15,180	148	15,032	8.2	5,684.3	0	620
6 June 1972	1030	20	--	7.7	2.0	205.0	8,371	34	8,337	0.8	3,996.9	0	2,100
6 Sep. 1972	1030	26	yes	7.5	1.4	189.0	16,841	5	16,836	1.6	8,068	0.5	6.2
6 Dec. 1972	1000	12	significant	7.1	6.7	125.0	722	42	680	0.2	3,605	7.1	13,000
4 Apr. 1973	0945	15	none	8.4	7.0	172.0	10,305	14	10,291	0.0	4,628.4	6.1	0.04
6 June 1973	1115	24	high	7.2	2.7	160.4	26,494	39	26,455	3.0	13,148	1.33	24
5 Sep. 1973	1000	21	yes	8.0	0.9	214.1	9,016	13	9,006	1.6	4,710	5.3	19,000
5 Dec. 1973	1030	13	0	7.1	1.7	162.8	15,306	11	15,295	0.6	8,078	6.6	240
6 Mar. 1974	0945	14	high	7.3	2.3	165.0	19,497	8	19,489	2.4	9,844	1.3	62,000
5 June 1974	1000	20	none	7.5	0.5	58.6	28,520	82	24,438	2.2	14,742	1.1	5
4 Sep. 1974	0930	22	turbid	7.8	1.4	136.0	30,195	25	30,170	7.6	16,822	1.4	6.2
11 Dec. 1974	1050	15	marked	7.0	1.8	153.2	24,317	40	24,277	6.6	13,085.6	0	6,200
2 Apr. 1975	1015	16	marked	8.4	3.1	188.5	13,763	8	13,755	2.2	8,264	5.8	240
7 May 1975	1035	19	marked	8.4	6.7	170.5	15,875	12	15,863	1.0	8,484	13.2	620

Source: California Regional Water Quality Control Board - Los Angeles Region, 1970-1975.

[a] Analysis in parts per million except as indicated.

[b] Temperature converted from Fahrenheit to Centigrade.

Table A2.1.5.2-5

1967 Water Quality[a] of Selected Los Angeles River Basin Streams

	Los Angeles River at Figueroa Street							
PARAMETER	1 Mar 67	16 Apr 67	3 May 67	12 May 67	7 Jun 67	5 Jul 67	2 Aug 67	1 Sep 67
Discharge (cfs)	28.6	20	9	10	13	6	7	293
Temp. (°C.)	19	18	20	18	21	24	32	26
pH	8.6	8.2	8.5	8.4	8.1	8.2	8.8	7.1
Total Hardness Non-Carbonate	352	325	298	316	360	294	303	220
Total Dissolved Solids	905	675	710	701	880	850	883	551
Calcium (Ca)	90	84	80	77	90	80	82	55
Magnesium (Mg)	31	28	24	30	33	23	24	20
Sodium (Na)	176	94	116	114	106	157	162	55
Nitrate (NO_3)	12.0	11.0	11.0	14.0	11.0	3.0	6.0	3.7
Dissolved Oxygen (DO)	16.1	10.0	21.0	16.8	13.0	13.8	16.0	2.7

Source: California Department of Water Resources, 1966, p. 13.

[a] Concentrations given in milligrams per liter except as indicated.

Table A2.1.5.2-5 (Continued)

PARAMETER	12 Oct 66	9 Nov 66	9 Dec 66	14 Jan 67	10 Feb 67	15 Mar 67	7 Apr 67	5 May 67
	Rio Hondo at Whittier Narrows							
Discharge (cfs)	177	6.0	203.0	92.0	65.0	11.8	164.0	101.0
Temp. (°C.)	24	17	14	13	13	16	15	17
pH	7.9	7.9	7.2	8.1	8.0	7.4	8.0	8.0
Total Hardness Non-Carbonate	356	313	77	352	338	250	344	351
Total Dissolved Solids	800	595	147	779	741	466	785	720
Calcium (Ca)	90	89	21	90	86	67	90	78
Magnesium (Mg)	32	22	6	31	30	20	29	38
Sodium (Na)	15	74	8	112	112	56	110	107
Nitrate (NO_3)	1.0	14.0	13.0	2.5	2.5	7.5	3.0	3.0
Dissloved Oxygen (DO)	9.4	2.4	6.8	10.6	9.4	5.2	9.8	10.2

Table A2.1.5.2-5 (Continued)

PARAMETER	Rio Hondo at Whittier Narrows 29 May 67	12 Jul 67	9 Aug 67	1 Sep 67
Discharge (cfs)	200.0	11.1	12.0	103.0
Temp. (°C.)	19	20	21	23
pH	8.1	7.9	7.4	7.6
Total Hardness Non-Carbonate	350	385	308	296
Total Dissolved Solids	773	671	572	640
Calcium (Ca)	86	100	79	74
Magnesium (Mg)	33	33	27	27
Sodium (Na)	110	51	72	89
Nitrate (NO_3)	2.5	10.0	18.6	4.0
Dissolved Oxygen (DO)	13.0	7.9	15.2	6.2

Table A2.1.5.2-6

Water Quality Data for San Gabriel River at Whittier Narrows, California

DATE	Time	Dissolved Sulfate (SO_4) (mg/l)	Dissolved Chloride (Cl) (mg/l)	Dissolved Solids (Residue at 180° C) (mg/l)	Dissolved Solids (Tons per ac-ft)	Hardness (Ca,Mg) (mg/l)	Specific Conductance (μmhos)	pH Units	Temperature C	Turbidity (JTU)	Dissolved Oxygen (mg/l)	Instantaneous Discharge (cfs)
22 Dec. 1969	1115	204	79	604	.87	284	963	7.7	18.3			
24 Mar. 1970	1045	163	88	615	.84	333	1030	7.4	19.4			
26 June 1970	0930	280	109	705	.96	327	1100	8.3	26.7			
29 Oct. 1970	1200	311	107	761	1.03	362	1185	8.4	17.0		11.5	
18 Dec. 1970	1100	131	69	456	.62	222	711	7.1	13.0		7.3	
26 Mar. 1971	1100	300	101	752	1.02	355	1138	7.9	15.5		13.1	
20 Sep. 1971	1415	299	99	730	.99	345	1119	7.8	26.0		10.8	
22 Oct. 1971	0945	309	101	735	1.00	348	1112	8.1	17.0	8	9.7	184
17 Dec. 1971	1630	308	101	719	.98	346		8.3	12.0	10	10.4	179
23 Mar. 1972	1000	155	105	633	.86	317	1130	8.3	19.5	2	15.2	8.0
30 June 1972	0915	159	108	635	.86	309	1100	8.1	21.5	2	10.1	10
28 Sep. 1972	1200	165	105	660	.90	330	1050	8.4	17.0	8	18.2	7.0
29 Dec. 1972	1000	300	98	719	.98	330	1150	8.2	7.0	8	13.4	214
13 Apr. 1973	1015	270	99	745	1.01	330	1050	8.4	17.0		15.8	94
28 June 1973	0915	290	98	747	1.02	340	1120	8.3	20.0	1	11.1	190
27 Sep. 1973	1015	280	98	730	.99	320	1100	7.8	23.0	2	7.6	148
21 Dec. 1973	1000	284	94	713	.97	328	1100	8.1	11.0	7	13.0	
29 Mar. 1974	0925	269	93	683	.93	320	1020	8.0	14.5	4	10.3	
20 June 1974	0945	195	130	774	1.05	328	1130	8.3	21.5	2	17.0	
26 Sep. 1974	1000	286	91	722	.98	322	1020	7.8	20.5	3	7.7	

Source: California Regional Water Quality Control Board -- Los Angeles Region, 1969-1974.

Table A2.1.5.2-7

1967 Water Quality Data[a] of Selected Santa Ana River Basin Streams

	Colorado River Aqueduct (upper feeder) at La Verne (Metropolitan Aqueduct)						
PARAMETER	7 Mar 67	5 Apr 67	12 May 67	14 Jun 67	7 Jul 67	7 Aug 67	6 Sep 67
Discharge (cfs)							
Temp. (°C.)	15	16	17	19	22		24
pH	8.4	8.4	8.4	8.4	8.3	8.3	8.3
Total Hardness Non-Carbonate	358	347	347	345	335	325	325
Total Dissolved Solids	734	732	728	722	706	694	680
Calcium (Ca)	89	88	88	87	84	80	80
Magnesium (Mg)	31	31	31	31	30	30	30
Sodium (Na)	108	110	109	107	105	105	101
Nitrate (NO_3)	1.7	1.7	1.3	1.4	0.7	0.5	0.5
Dissolved Oxygen (DO)					9.8		

Source: California Department of Water Resources, 1966, p. 13.

[a] Concentrations given in milligrams per liter except as indicated.

Table A2.1.5.2-7 (Continued)

PARAMETER	11 Oct 66	4 Nov 66	7 Dec 66	21 Mar 66	5 Apr 67
	San Timoteo Creek Near San Bernardino				
Discharge (cfs)	0.5	2.0	4.0	5.0	3.0
Temp. (°C.)	19	18	18	25	22
pH	7.9	8.0	7.5	7.5	8.0
Total Hardness Non-Carbonate	149	181	120	130	
Total Dissolved Solids	345	320	288	260	172
Calcium (Ca)	55	55	36	39	27
Magnesium (Mg)	14	12	8	8	5
Sodium (Na)	56	36	43	34	20
Nitrate (NO_3)	25.5	36.0	5.0	14.0	1.5
Dissolved Oxygen (DO)	10.4	11.0	8.6	10.0	7.8

Table A2.1.5.2-8

Water Quality Data for Santa Ana River Below Prado Dam, California

DATE	Time	Instantaneous Discharge (cfs)	Sodium Adsorption ratio	Specific Conductance (μmhos)	pH (units)	Temperature (Deg)	Turbidity (JTU)	Dissolved Oxygen (mg/l)	Dissolved Nitrate plus Nitrate (N) (mg/l)	Total Kjeldahl Nitrogen (N) (mg/l)	Alkalinity as $CaCO_3$ (mg/l)	Dissolved solids (Residue at 180° C) (mg/l)	Dissolved Solids (Tons per ac-ft)	Hardness (Ca,Mg) (mg/l)
19 Dec. 1969	1430		2.7	1340	7.9	15.0		9.1			317	858	1.17	428
23 Mar. 1970	1400		2.2	1040	7.8	15.6		9.3			236	618	.84	331
25 June 1970	1330		2.7	1230	8.1	31.7		6.2			275	796	1.08	393
28 Sep. 1970	1400		2.6	1230	8.3	27.2		7.8			266	771	1.05	387
17 Dec. 1970	1545		2.5	1274	7.5	12.0		8.1			294	851	1.16	441
25 Mar. 1971	1400		2.5	1260	7.6	18.0		8.9			288	764	1.04	407
17 June 1971	1400		2.6	1192	8.2	29.0		7.0			267	751	1.02	384
22 Sep. 1971	1000		2.7	1377	8.1	20.5		8.4			344	850	1.16	468
16 Dec. 1971	1530	50	2.7	1400	8.0	9.0	44	10.1			285	794	1.08	406
05 Jan. 1972	1530	233	2.2	1200	7.4	8.0	32	8.4			215	639	.87	309
24 Mar. 1972	1330	70	2.6	1250	7.9	22.0	70	7.7			267	693	.94	347
29 June 1972	1310	37	2.5	1230	8.1	28.0	42	7.3			259	720	.98	380
29 Sep. 1972	0815	50	2.6	1280	7.9	19.0	45	7.5			271	778	1.06	384
30 Dec. 1972	1320	66	2.7	1200	7.7	9.5	26	10.2			262	745	1.01	370
01 Mar. 1973	0800	185	1.9	740	7.2	11.0	20	6.9			213	495	.67	240
29 June 1973	0700	48	2.5	1130	7.8	19.5	33	7.4			238	746	1.01	350
28 Sep. 1973	0730	3.0	2.4	1400	8.0	16.0	5	9.9			328	969	1.32	540
20 Dec. 1973	1330		2.7	1100	7.7	12.0	30	9.7			241	725	.99	344
28 Mar. 1974	1300		2.1	720	7.6	15.5		9.0			162	484	.66	220
21 June 1974	0715		2.0	600	7.7	15.5	50	8.8			128	378	.51	184
27 Sep. 1974	0720		1.8	600	7.6	18.5	31	7.5			121	395	.54	175

Source: California Regional Water Quality Board -- Santa Ana Region, 1969-1974.

Table A2.1.5.2-9

Water Quality Data for Santa Ana River at Colton, California

DATE	Time	Discharge (cfs)	Temperature (Deg C)	Dissolved Oxygen (mg/l)	Nitrate (N03) (mg/l)	Boron (B) (μg/l)	Dissolved Solids (Residue at 180°C) (mg/l)	Dissolved Solids (Tons per ac-ft)	Hardness (Ca,Mg) (mg/l)	Sodium Adsorption Ratio	Alkalinity as $CaCO_3$ (mg/l)	pH Units	Specific Conductance (micro μmhos)
17 Oct. 1968	1245	16	27	9.3	22	560	584	.79	190	3.6	258	7.5	1030
18 Nov. 1968	1200	16	25	8.6	15	530	551	.75	196	2.8	264	7.6	969
19 Dec. 1968	1230	15	17	9.2	21	560	596	.81	187	3.4	260	7.3	1060
16 Jan. 1969	1400	20	22	8.7	18	500	583	.79	201	3.1	229	7.5	1060
20 Feb. 1969	1300	194	19	9.3	22		440	.60	171	2.2	161	7.5	751
21 Mar. 1969	1145	570	13	9.9	14	90	246	.33	143	.9	125	7.9	401
24 Apr. 1969	1215	486	23	8.4	16	90	240	.33	148	.9	126	7.9	405
21 May 1969	1200	538	20	8.9	10	60	206	.28	153	.6	135	7.8	369
19 June 1969	1315	278	29	7.1	28	160	264	.36	145	1.3	119	7.1	452
28 July 1969	1230	146	30	7.2	22	30	264	.36	157	.9	130	7.2	440
19 Aug. 1969	1000	68	26	7.9	18	130	250	.34	169	1.3	142	8.3	505
18 Sep. 1969	1400	44	11	6.7	39	280	381	.52	178	2.3	147	6.8	645

Source: U.S. Geological Survey Water Supply Paper 2149, 1974, p.29.

Table A2.1.5.2-10

Water Quality Data for Whitewater River at White Water, California

DATE	Time	Temperature[a] (Deg C)	Dis-Charge (cfs)	pH	Specific Conductance (µmhos/Cm)	Total Hardness (CaCO3) (Meg/l)	Total Cations (Meg/l)	Total Anions (Meg/l)	Dissolved Boron (B) (Meg/l)	Total Dissolved Solids at 180°	Turbidity[b] (JTU)
17 Mar. 1969	1225	17	115	8.3	329	155	3.63	3.57	0.00	189	30
23 June 1969	1015	20		8.3	254	115	2.72	2.70	0.00	132	<25
22 Sep. 1969	1045	20		8.3	321	150	3.57	3.51	0.00	163	25
15 Dec. 1969	1215	14	40	8.3	339	150	3.57	3.54	0.00	193	<25
19 Mar. 1970	0845	9	29	8.5	328	146	3.48	3.49	0.00	183	<25
22 June 1970	1130	26		7.6	340	150	3.61	3.62	0.00	189	<25
21 Sep. 1970	1230	24		8.1	331	145	3.52	3.43	0.00	191	<25
14 Dec. 1970	1330	15	1.9	8.0	353	162	3.86	3.77	0.00	198	32
22 Mar. 1971	1115	20	3.8	8.2	367	166	3.99	3.91	0.00	210	<25
28 June 1971	1400	26	5.6	8.1	368	201	4.00	3.99	0.01	201	<25
13 Sep. 1971	1015	25	10	7.8	344	154	3.78	3.86	0.01	193	26
26 Dec. 1972	0830	12	3.8	7.9	408	183	4.41	4.50	0.00	221	2
26 Mar. 1973	0800	9	18.0	7.9	369	168	3.96	3.90	0.00	189	60
25 June 1973	0730	18	15.0	8.1	402	174	4.14	4.16	0.00	235	2
24 Sep. 1973	0745	17	10.0	8.0	511	181	4.38	4.38	0.00	200	2
17 Dec. 1973	0900	14	5.0	8.1	397	181	4.34	4.38	0.00	226	
25 Mar. 1974	0730	11	5.0	7.4	393	165	3.91	3.95	0.00	242	
17 June 1974	0730	17	7.1	7.9	425	182	4.32	4.22	0.00	243	4
23 Sep. 1974	0730	19	9.0	7.8	398	171	4.10	4.10	0.00	241	6
16 Dec. 1974	0900	13		8.2	394	177	4.18	4.26	0.00	250	47
24 Mar. 1975	0800	10		8.2	363	161	3.81	3.83	0.00	188	55
23 June 1975	0730	18		7.8	414	185	4.39	4.33	0.00	252	0

Source: Department of Water Resources, Southern District.

[a] Temperature converted from Fahrenheit to Centigrade.

[b] Mach units for turbidity used from December, 1972, through June, 1975.

Table A2.1.5.2-11

Representative Water Quality[a] of Coachella Valley Streams

STREAM	Date	Discharge cfs	Temp. °C	pH	Total Hardness	Percent Na	Total dis-solved solids	Fluoride F	Silica SiO_2	Boron B
San Gorgonio River Near Banning	7 Apr. 58	100	11	7.8	134	18	209	0.08	12	1
Snow Creek Sec. 33 T. 3 S., R. 3 E.	28 Feb. 58	10	6	7.8	20	47	55	1.0	17	0.0
Tahquitz Creek Sec. 22 T. 4 S., R. 5 E.	16 Mar. 60	2+	15	7.9	50	33	84	0.1	20	0.06
Mission Creek NW/4, Sec. 24 T. 3 S., R. 4 E.	7 Apr. 58	ponded		7.3	100	11	118	0.11	20	0.0

Source: Modified from California Department of Water Resources, 1964, p.8.

[a] Concentrations given in parts per million by weight except where indicated.

Table A2.1.5.2-12

Water Quality Data[a] For Colorado River Below Cibola Valley, Arizona

DATE	Time	Dis-charge	Chlo-ride (Cl)	Dis-solved Solids (sum of constit-uents)	Dis-solved Solids (Tons per ac-ft.)	Hard-ness (Ca, Mg)	Dis-solved Nitrate Plus Nitrate (N)	Dis-solved Boron (B)	Speci-fic Conduc-tance (µmhos)	pH (units)	Temperature (C)
24 Jan. 1969			208	1050	1.43	440			1730	7.9	
10 Sep. 1969		6640	152	870	1.18	400			1440	8.1	
22 Dec. 1969	1230	4500	151	876	1.19	400			1460	8.0	
16 Mar. 1970	1000	10320	115	825	1.17	380			1320	8.1	15.0
8 Jun. 1970			115	852	1.22	380			1350	7.9	
18 Sep. 1970	0855		104	793	1.15	365			1250	8.2	25.0
7 Dec. 1970			135	933	1.31	400			1470	8.1	
3 Mar. 1971			150	958	1.32	420	.40	230	1390	8.3	
9 Jun. 1971			120	818	1.18	370	.32	160	1250	8.0	
7 Sep. 1971			110	794	1.09	350	.29	160	1200	7.6	
6 Dec. 1971			120	868	1.17	380	.33	120	1300	8.1	
6 Mar. 1972	0800		130	871	1.19	380	.47	110	1330	8.1	
30 May 1972	0700		130	878	1.22	380	.34	210	1360	8.1	
5 Sep. 1972	0750		130	835	1.16	360	.18	200	1310	8.0	
4 Dec. 1972	0900		150	926	1.25	380	.29	230	1430	7.6	
5 Mar. 1973	1400		130	853	1.16	370	.38	190	1300	8.2	15.0
4 Jun. 1973	1300	7130	170	1020	1.41	390	.27	250	1580	7.9	26.0
4 Sep. 1973	1315		150	957	1.27	380	.14	230	1430	8.2	26.5

Source: Modified from U.S. Geological Survey, 1970d, 1971, 1972, 1973a.

[a] Concentrations in mg/l.

Table A2.1.5.2-13

Groundwater Resources Inventory for the South Coastal Basin

BASIN NAME, COUNTY	Basin Number	Basin description: size, major stream water bearing material	Well yields in gpm Max.	Well yields in gpm Aver.	Depth zone in feet	Storage capacity in acre-feet	Usable capacity in acre-feet	Development of ground-water within basin [a]
Coastal Plain of Los Angeles Los Angeles County	4-11	A 500-square-mile coastal plain drained mainly by the Los Angeles and San Gabriel Rivers. Younger alluvium.	2,000	600	1960 water levels to 2,000 feet below ground surface	31,730,000	2,363,000	Intensive for municipal, moderate for industrial, and limited for irrigation uses. 1973-74 extractions about 280,000 ac. ft./yr. A potential for limited additional development.
San Gabriel Valley Los Angeles County	4-13	A 200-square-mile basin drained by the Rio Hondo and San Gabriel River. Younger alluvium.	4,850	1,000	Average ground surface elevation to base of freshwater	10,438,000	Unknown	Moderate to intensive for municipal and industrial use. Limited for irrigation and domestic use. Recharge under 1960 cultural conditions 166,000 ac. ft./yr. 1974 extractions about 250,000 ac. ft./yr. A potential for limited additional development.
Upper Santa Ana Valley Los Angeles County	4-14	A 30-square-mile basin drained by Live Oak and Thompson Washes. Younger alluvium.	750	100	1960 water levels to base of freshwater	750,000	Unknown	Moderate to intensive for irrigation and municipal use. Limited for industrial and domestic use. A potential for limited additional development.
Upper Santa Ana Valley Riverside and San Bernardino Counties	8-2	A 620-square-mile basin drained primarily by the Santa Ana River. Younger and older alluvium.	4,500	800	1960 water levels to base of freshwater	16,000,000	2,000,000	Moderate to intensive for irrigation, municipal and industrial uses. Limited for domestic use. Safe yield about 230,000 ac. ft./yr. 1970 groundwater extractions about 460,000 ac. ft./yr. A potential for limited additional development.
San Jacinto Basin Riverside County	8-5	A 235-square-mile basin drained by the San Jacinto River. Younger and older alluvium.	1,000	100	Between 1960 water table and 2,000 ft below ground surface	6,100,000	1,300,000	Moderate for irrigation and municipal use. Limited for domestic use. Natural recharge estimated at about 4,000 ac. ft./yr. A potential for limited additional development.

Source: California Department of Water Resources, 1975.

[a] Evaluation of Groundwater Development Presented in Table A2.1.5.2-13

EVALUATION	Degree of Knowledge: Geologic Criteria	Degree of Knowledge: Hydrologic Criteria
Intensive	Detailed identification (names) and description of aquifers and detailed data on transmissivity (model).	Detailed information on recharge, occurrence, movement, disposal, and changes in storage (can model).
High	Detailed identification and description of aquifers but minimum data on transmissivity.	General information on recharge, occurrence, movement and disposal.
Moderate	Moderate subsurface data available enabling the general description of aquifers and occasional naming.	Moderate information on occurrence, and movement and recharge and disposal.
Limited	Limited subsurface data on free and confined water bodies.	Limited information on occurrence and movement based mainly on water level data.
Superficial	Limited to knowledge that groundwater occurs.	Limited to knowledge that groundwater occurs.

Table A2.1.5.2-14

Records of Selected Wells

LOCATION[a] (Township, Range, Section)	Total Depth (ft)	Depth of Perforated Interval	Water Level Date (mo/yr)	Water Level Depth (ft)	Water-bearing Unit
Coastal Plain of Los Angeles, California					
4 S., 13 W., 12			11-72	61	Recent alluvium
			8-73	136	Recent alluvium
3 S., 13 W., 25			4-73	86	Recent alluvium
3 S., 12 W., 18			4-73	62	Recent alluvium
2 S., 12 W., 31			4-73	104	Recent alluvium
2 S., 12 W., 21			10-72	115	Recent alluvium
San Gabriel Valley, California					
1 S., 11 W., 31			9-73		Recent alluvium
1 S., 11 W., 21			10-72	259	Recent alluvium
			9-73	182	Recent alluvium
2 S., 10 W., 10			4-73	38	Recent alluvium
2 S., 9 W., 4			4-73	44	Recent alluvium
Upper Santa Ana Valley, California					
1 S., 8 W., 26			11-72	392	Recent alluvium
2 S., 8 W., 5			5-73	224	Recent alluvium
2 S., 8 W., 15			4-73	116	Recent alluvium
2 S., 7 W., 17			4-73	117	Recent alluvium
2 S., 7 W., 15			4-73	119	Recent alluvium
1 S., 6 W., 27			9-73	243	Recent alluvium
1 S., 5 W., 16			9-73	417	Recent alluvium
1 S., 5 W., 36			4-73	49	Recent alluvium
1 S., 4 W., 28			8-73	61	Recent alluvium

Source: Williams Brothers Engineering Company (May 1976); Metzger et al. (1973); Briggs (1969); Denis (1975); Stulik and Laney (1976); White (1963); Denis (1975); Babcock (1974); Reider (1957); Hale et al. (1965); Leggatt et al. (1963); Sayre and Livingston (no date); Mount et al. (1967). Sources are listed in the same order as the geographical areas to which they relate.

[a] Well locations identified on Maps 2.1.5-1 through 2.1.5-12, Attachment 1.

Table A2.1.5.2-14 (Continued)

LOCATION[a] (Township, Range, Section)	Total Depth (ft)	Depth of Perforated Interval	Water Level Date (mo/yr)	Water Level Depth (ft)	Water-bearing Unit
1 S., 4 W., 28			4-73	46	Recent alluvium
1 S., 4 W., 34			9-73	126	Recent alluvium
1 S., 3 W., 31			11-72	200	Recent alluvium
2 S., 2 W., 20			4-73	24	Recent alluvium
2 S., 1 W., 27			9-73	552	Recent alluvium
Coachella Valley, California					
2 S., 1 E., 29			10-72	72	Older alluvium
			9-73	26	Older alluvium
3 S., 1 E., 7			9-73	303	Older alluvium
3 S., 2 E., 23			5-73	312	Older alluvium
3 S., 3 E., 7			9-73	343	Older alluvium
3 S., 4 E., 23			6-73	168	Older alluvium
3 S., 5 E., 6			9-73	120	Older alluvium
3 S., 5 E., 22			4-73	107	Older alluvium
4 S., 6 E., 8			9-73	238	Older alluvium
4 S., 7 E., 32			6-73	67	Older alluvium
5 S., 8 E., 17			9-73	76	Older alluvium
5 S., 8 E., 34			1-73	111	Older alluvium
6 S., 9 E., 32			9-73	182	Older alluvium
Colorado River Valley, Arizona and California					
7 S., 21 E., 14	1,363	700-900	3-66	130	Pre-Bouse fanglomerate
7 S., 22 E., 11	460		2-62	8	Colorado River alluvium
7 S., 22 E., 17	260		1-61	7	Colorado River alluvium
7 S., 23 E., 17	176	112-147			Colorado River alluvium
2 N., 22 W., 16	998	820-985	10-64	10	Pre-Bouse fanglomerate
3 N., 21 W., 7	454	423-443	2-64	193	Colorado River alluvium

Table A2.1.5.2-14 (Continued)

LOCATION[a] (Township, Range, Section)	Total Depth (ft)	Depth of Perforated Interval	Water Level Date (mo/yr)	Water Level Depth (ft)	Water-bearing Unit
3 N., 22 W., 27	18	17-18	7-61	10	Colorado River alluvium
		Ranegras Plain, Arizona			
2 N., 14 W., 10	455	340-380	4-68	332	Older alluvium
3 N., 15 W., 2			4-68	188	Older alluvium
3 N., 15 W., 23	318		8-67	282	Older alluvium
4 N., 14 W., 30	250		8-67	187	Older alluvium
4 N., 15 W., 23			4-68	179	Older alluvium
		Harquahala Plains, Arizona			
1 S., 8 W., 6	710	154-710	1-74	375	Older alluvium
1 S., 8 W., 14	225	20-225	1-75	224	Older alluvium
1 N., 9 W., 14	1,216	600-1,216	1-75	447	Older alluvium
1 N., 9 W., 17	1,495	945-1,495	1-75	448	Older alluvium
1 N., 9 W., 24	1,000		1-75	415	Older alluvium
1 N., 10 W., 1	918	340-777	1-75	440	Older alluvium
		Centennial Area, Arizona			
1 S., 6 W., 18	1,333	1,300-1,333	2-73	206	Older alluvium
1 S., 6 W., 21	1,012	229-1,012	1-70	175	Older alluvium
1 S., 6 W., 26	1,130	200-1,130	12-71	171	Older alluvium
1 S., 6 W., 28	337	124-337			Older alluvium
1 S., 6 W., 31			5-70	196	Older alluvium
1 S., 7 W., 15	650	164-650	2-73	227	Older alluvium
1 S., 7 W., 22	187		6-69	152	Older alluvium
2 S., 5 W., 8			1-70	62	Older alluvium
2 S., 5 W., 18	793	206-793	5-70	104	Older alluvium
		Gila Bend Basin, Arizona			
2 S., 4 W., 26	428		3-60	269	Older alluvium
2 S., 4 W., 31	452	150-452	1-61	219	Older alluvium
2 S., 4 W., 32	450		1-61	247	Older alluvium

Table A2.1.5.2-14 (Continued)

LOCATION[a] (Township, Range, Section)	Total Depth (ft)	Depth of Perforated Interval	Water Level Date (mo/yr)	Water Level Depth (ft)	Water-bearing Unit
		Waterman Wash, Arizona			
2 S., 2 W., 8			-75	306	Older alluvium
2 S., 2 W., 23	1,263	205-1,200	-75	333	Older alluvium
3 S., 1 W., 9			-75	231	Older alluvium
4 S., 1 E., 28	504		-75	406	Older alluvium
		Lower Santa Cruz Basin, Arizona			
5 S., 2 E., 22	595	200	1-74	589	Older alluvium
6 S., 2 E., 1	551	150	1-74	623	Older alluvium
6 S., 3 E., 1	410		4-70	504	Older alluvium
6 S., 4 E., 2	950	450	1-71	473	Older alluvium
6 S., 4 E., 7	307	103	1-74	489	Older alluvium
6 S., 4 E., 10	1,200	453	12-57	237	Older alluvium
6 S., 6 E., 6	92	44	1-73	197	Older alluvium
6 S., 7 E., 12	400	160	1-73	218	Older alluvium
6 S., 8 E., 4	385	87	6-59	250	Older alluvium
6 S., 8 E., 4			1-73	159	Older alluvium
6 S., 8 E., 21	240		1-73	206	Older alluvium
6 S., 8 E., 21	497	424	9-73	295	Older alluvium
6 S., 9 E., 4	556	200	1-73	285	Older alluvium
6 S., 10 E., 29	355	110		170	Older alluvium
6 S., 11 E., 27	300		1-74	28	Older alluvium
7 S., 12 E., 13	80		Sealed		Older alluvium
8 S., 12 E., 19	38		1-74	12	Older alluvium
8 S., 13 E., 8	570		10-52	13	Older alluvium
8 S., 13 E., 15			11-41	50	Older alluvium
9 S., 14 E., 20	660		11-65	516	Older alluvium
9 S., 14 E., 34			11-72	3,695	Older alluvium

Table A2.1.5.2-14 (Continued)

LOCATION[a] (Township, Range, Section)	Total Depth (ft)	Depth of Perforated Interval	Water Level Date (mo/yr)	Water Level Depth (ft)	Water-bearing Unit
		San Pedro Valley, Arizona			
9 S., 15 E., 36	225		8-49	74	Granite
10 S., 17 E., 15	285		8-49	215	
11 S., 18 E., 10	210		3-54	45	Older alluvium
12 S., 19 E., 19	80		12-49	46.6	Older alluvium
		Sulphur Springs Valley, Arizona			
13 S., 21 E., 16	250		7-51	154	
13 S., 21 E., 16	215		7-51	149	
13 S., 21 E., 20	400		12-50	314	
13 S., 22 E., 33	1,435		11-62	700	
13 S., 24 E., 1	68		3-49	56	
13 S., 24 E., 17	500	165	1-74	123	Older alluvium
13 S., 24 E., 17	505	180	1-59	80	Older alluvium
13 S., 25 E., 30			3-49	26.4	
13 S., 25 E., 30					
14 S., 21 E., 11	415		1-74	339	
		San Simon Basin, Arizona			
12 S., 27 E., 32	250		1-74	133	
13 S., 28 E., 11	504	300	3-72	344	Older alluvium
13 S., 28 E., 16	895	437	1-74	395	Older alluvium
13 S., 28 E., 16	671	200	1-53	200	Older alluvium
13 S., 29 E., 25	863	403	1-74	88	Older alluvium
13 S., 29 E., 25	795	500	5-64	150	Older alluvium
13 S., 30 E., 9	900		1-74	48	Older alluvium
13 S., 30 E., 9	92		11-40	23	Older alluvium
13 S., 30 E., 25	880		1-74	82	Older alluvium
13 S., 30 E., 25	900		4-41	4	Older alluvium
13 S., 30 E., 25	154	76	4-59	76	Older alluvium
13 S., 30 E., 25	88		12-40	63	Older alluvium

Table A2.1.5.2-14 (Continued)

LOCATION[a] (Township, Range, Section)	Total Depth (ft)	Depth of Perforated Interval	Water Level Date (mo/yr)	Water Level Depth (ft)	Water-bearing Unit
13 S., 30 E., 25	73		12-40	60	Older alluvium
13 S., 31 E., 6	120	80	11-59	46	Older alluvium
Animas and Lordsburg Valley, New Mexico					
22 S., 18 W., 21	174		6-55	113.2	Older alluvium
22 S., 18 W., 29			6-55	109.8	Older alluvium
22 S., 19 W., 24			6-55	91.5	Older alluvium
22 S., 20 W., 18	300		6-55	275	Older alluvium
22 S., 21 W., 32	125		6-55	115.6	Older alluvium
23 S., 19 W., 7			6-55	120.2	Older alluvium
23 S., 20 W., 13					Older alluvium
23 S., 21 W., 35			6-55	56.9	Older alluvium
24 S., 17 W., 11	250				Older alluvium
Mimbres Basin, New Mexico					
24 S., 7 W., 9	285				Older alluvium
24 S., 9 W., 6	1,000				Older alluvium
24 S., 11 W., 12	1,500				Older alluvium
Rio Grande Valley, New Mexico and Texas					
25 S., 1 W., 16			5-68	395	Santa Fe Group
25 S., 2 W., 9			5-68	480	Santa Fe Group
25 S., 2 W., 5			5-68	124	Santa Fe Group
25 S., 3 W., 8	296		6-68	202	Santa Fe Group
25 S., 4 W., 3	200		6-68	183	Santa Fe Group
25 S., 1 E., 21	586			410	Santa Fe Group
25 S., 2 E., 31	360			380	Santa Fe Group
26 S., 3 E., 4			1-65	9.9	Santa Fe Group
26 S., 3 E., 15			1-65	8.9	Santa Fe Group
26 S., 4 E., 19			6-68	179	Santa Fe Group
26 S., 4 E., 24	520		6-68	384	Santa Fe Group

Table A2.1.5.2-14 (Continued)

LOCATION[a] (Township, Range, Section)	Total Depth (ft)	Depth of Perforated Interval	Water Level Date (mo/yr)	Water Level Depth (ft)	Water-bearing Unit
Hueco Bolson, New Mexico and Texas					
JL49-12-102 (137)[b]	323		7-29	273	Santa Fe Group
JL49-04-723 (138)			7-37	268	Santa Fe Group
JL49-04-724 (139)	360		7-38	297	Santa Fe Group
26 S., 6 E., 34 (140)	400		7-38	284	Santa Fe Group
49-11-302 (143)[c]	350		6-37	314	Santa Fe Group
26 S., 5 E., 21 (144)	340		6-33	310	Santa Fe Group
26 S., 5 E., 19 (145)	520		6-37	381	Santa Fe Group
JL49-12-103 (153)	400		6-37	363	Santa Fe Group
Midland area, Texas					
TJ27-63-601			11/75	96	Ogallala
TJ27-63-705	127		11/75	61	Ogallala
TJ27-64-401	127		11/75	97	Ogallala
TJ27-64-901	69		11/75	49	Ogallala
TJ28-57-901			11/75	91	Ogallala
TJ44-01-102			11/75	45	Ogallala
TJ44-01-103			11/75	82	Ogallala
TJ44-01-401			11/75	37	Ogallala
TJ45-08-504			11/75	59	Ogallala
TJ45-08-602	76		11/75	60	Ogallala
A-3[d]	110		4/47	94	

[b] Location of well numbers in Texas are identified by county, latitude/longitude grid. Alpha digits identify by county: JL, El Paso County; TJ, Midland County. Numbers in parenthesis indicate identification number of wells on Map 2.1.5-10, Attachment 1.

[c] Well 49-11-302 is located in New Mexico but is assigned a Texas grid number without a county designation.

[d] Well numbers from Knowles (1952).

Table A2.1.5.2-14 (Continued)

LOCATION[a] (Township, Range, Section)	Total Depth (ft)	Depth of Perforated Interval	Water Level Date (mo/yr)	Water Level Depth (ft)	Water-bearing Unit
A-11	100		4/37	59	
B-4	48		4/37	32	
C-1	113		11/47	72	
C-10	48		2/37	38	

Table A2.1.5.2-15

Chemical Analyses[a] of Water From Selected Wells

PARAMETER	Location[b] Township, Range, Section, or Well Number				
	Colorado River Valley, Arizona and California				
	7S,21E,14	7S,23E,17	2N,22W,16	3N,21W,7	3N,22W,27
Date sampled (mo/yr)	3/66	2/62	9/64	6/63	4/62
Depth to water (ft)	130	176	10	193	10
Silica (SiO_2)	45	17	50	18	21
Calcium (Ca)	150	129	326	40	170
Magnesium (Mg)	14	36	0.2	4.9	70
Sodium (Na)	1,510	239	1,200	229	329
Potassium (K)			10		
Bicarbonate (HCO_3)	65	302	28	90	548
Carbonate (CO_3)					
Sulfate (SO_4)	800	375	648	275	675
Chloride (Cl)	1,990	249	1,930	182	194
Fluoride (F)	5.2		3.5	0.5	
Nitrate (NO_3)			0.2		
Total dissolved solids	4,550	1,200	4,180	794	1,730
Hardness as $CaCO_3$ Calcium, magnesium	430	468	815	120	710
Noncarbonate	376	220	792	46	260
Specific conductance (micromhos at 25° C)	7,680	1,880	6,910	1,330	2,650
pH	7.5	7.7	7.3	7.4	7.4

[a] Analyses in milligrams per liter, except as indicated.

[b] Well locations identified on Maps 2.1.5-1 through 2.1.5-12, Attachment 1.

Table A2.1.5.2-15 (Continued)

PARAMETER	Location[b] Township, Range, Section, or Well Number	
	Ranegras Plain, Arizona	
	4N,14W,30	4N,15W,28
Date sampled (mo/yr)	11/48	11/48
Depth to water (ft)	187	
Silica (SiO_2)	15	35
Calcium (Ca)	10	25
Magnesium (Mg)	1.9	5.0
Sodium (Na) / Potassium (K)	271	262
Bicarbonate (HCO_3)	106	77
Carbonate (CO_3)	0	0
Sulfate (SO_4)	136	166
Chloride (Cl)	250	265
Fluoride (F)	8.9	5.1
Nitrate (NO_3)	21	38
Total dissolved solids	776	839
Hardness as $CaCO_3$ Calcium, magnesium	33	83
Noncarbonate	0	20
Specific conductance (micromhos at 25° C)	1,370	1,440
pH		7.3

Table A2.1.5.2-15 (Continued)

PARAMETER	Location[b] Township, Range, Section, or Well Number					
	Harquahala Plains, Arizona					
	1S,8W,6	1S,8W,14	1N,9W,14	1N,9W,17	1N,9W,24	1N,10W,1
Date sampled (mo/yr)	7/58	7/53	8/57	7/58	8/58	6/53
Depth to water (ft)	375	224	447	448	415	440
Silica (SiO_2)	30	50	130	30	49	27
Calcium (Ca)	16	16	27	16	12	25
Magnesium (Mg)	7.2	4.4	0.9	8.1	3.7	15
Sodium (Na) Potassium (K)	218	204	301	202	172	191
Bicarbonate (HCO_3)	168	207	178	286	178	302
Carbonate (CO_3)	0	0	40	0	0	0
Sulfate (SO_4)	158	129	393	122	111	122
Chloride (Cl)	156	124	65	93	102	104
Fluoride (F)	5.1	4.8	2.3	2.8	2.1	2.8
Nitrate (NO_3)	11	11	8.9	16	9.5	13
Total dissolved solids	684	645	1,060	631	549	649
Hardness as $CaCO_3$ Calcium, magnesium	70	58	71	74	45	124
Noncarbonate	0	0	0	0	0	0
Specific conductance (micromhos at 25° C)	1,130	1,030	1,430	1,010	868	1,070
pH	8.1		8.1	8.1	7.5	

PARAMETER	Location[b] Township, Range, Section, or Well Number				
	Centennial Area, Arizona				
	1S,6W,18	1S,6W,21	1S,6W,26	1S,6W,28	2S,5W,8
Date sampled (mo/yr)	7/53	8/68	7/53	8/69	8/68
Depth to water (ft)	206	175	171		62
Silica (SiO_2)	46		50		
Calcium (Ca)	19		45		
Magnesium (Mg)	11		17		
Sodium (Na) / Potassium (K)	387		278		
Bicarbonate (HCO_3)	324		126		
Carbonate (CO_3)					
Sulfate (SO_4)	275		222		
Chloride (Cl)	246		308		
Fluoride (F)	10		2.6		
Nitrate (NO_3)	11		13		
Total dissolved solids	1,160		998		
Hardness as $CaCO_3$ Calcium, magnesium	92		182		
Noncarbonate	0		80		
Specific conductance (micromhos at 25° C)	1,880	1,650	1,650	2,350	1,400
pH					

Table A2.1.5.2-15 (Continued)

PARAMETER	Location[b] Township, Range, Section, or Well Number		
	Gila Bend Basin, Arizona		
	2S,4W,26	2S,4W,31	2S,4W,32
Date sampled (mo/yr)	9/60	5/53	5/53
Depth to water (ft)			
Silica (SiO_2)	36	30	29
Calcium (Ca)	64	96	80
Magnesium (Mg)	2.6	28	6.1
Sodium (Na) / Potassium (K)	373	352	482
Bicarbonate (HCO_3)	143	237	95
Carbonate (CO_3)	0	0	0
Sulfate (SO_4)	132	139	181
Chloride (Cl)	498	550	702
Fluoride (F)	4.3	1.2	5.0
Nitrate (NO_3)	16	4	2.6
Total dissolved solids	1,200	1,320	1,530
Hardness as $CaCO_3$ Calcium, magnesium	170	354	224
Noncarbonate	53	160	146
Specific conductance (micromhos at 25° C)	2,110	2.330	2,730
pH	6.6		

Table A2.1.5.2-15 (Continued)

PARAMETER	Location[b] Township, Range, Section, or Well Number				
	Waterman Wash, Arizona				
	2S,2W,8	2S,2W,23	3S,1W,9	4S,1E,26	4S,1E,28
Date sampled (mo/yr)	9/60	4/52	8/49	8/49	8/49
Depth to water (ft)	306	333	231		406
Silica (SiO_2)	27	20	28	39	33
Calcium (Ca)	6	17	51	55	48
Magnesium (Mg)	1.2	3.4	14	16	13
Sodium (Na) Potassium (K)	172	264	41	227	131
Bicarbonate (HCO_3)	322	101	321	195	209
Carbonate (CO_3)	0	0	0	0	0
Sulfate (SO_4)	19	116	3.7	223	109
Chloride (Cl)	56	282	3	206	111
Fluoride (F)	7.3	2.6	0.2	1.2	0.5
Nitrate (NO_3)	16	28	3.2	13	20
Total dissolved solids	462	783	302	876	568
Hardness as $CaCO_3$ Calcium, magnesium	20	56	184	203	174
Noncarbonate	0	0	0	43	2
Specific conductance (micromhos at 25° C)	766	1,370	493	1,420	923
pH	7.6				

Table A2.1.5.2-15 (Continued)

PARAMETER	Location[b] Township, Range, Section, or Well Number				
	Lower Santa Cruz Basin, Arizona				
	S, 2E, 22	6S, 3E, 1	6S, 4E, 7	6S, 8E, 4	6S, 8E, 21
Date sampled (mo/yr)	9/41	9/41	9/41	9/41	9/41
Depth to water (ft)	589	504	489	159	206
Silica SiO_2					
Calcium (Ca)	51			144	
Magnesium (Mg)	10			30	
Sodium (Na)					
Potassium (K)					
Bicarbonate (HCO_3)	149	185	183	175	115
Carbonate (CO_3)	0	0	0	0	0
Sulfate (SO_4)	200			264	
Chloride (Cl)	212	24	24	285	121
Fluoride (F)	3				
Nitrate (NO_3)	14				
Total dissolved solids	784			964	
Hardness as $CaCO_3$ Calcium, magnesium	168			483	
Noncarbonate					
Specific conductance (micromhos at 25° C)	136	493	498	1,620	807
pH					

Table A2.1.5.2-15 (Continued)

Lower Santa Cruz Basin, Arizona (Continued)

PARAMETER	Location[b] Township, Range, Section, or Well Number				
	6S,11E,27	7S,12E,13	8S,12E,19	8S,13E,8	8S,13E,15
Date sampled (mo/yr)	5/57	7/73	7/73	10/52	7/73
Depth to water (ft)	28	Sealed	12	13	50
Silica (SiO_2)		29	51		54
Calcium (Ca)		71	92	94	80
Magnesium (Mg)		9.3	33	24	24
Sodium (Na)		10	100		150
Potassium (K)		8.5	5.4		2.3
Bicarbonate (HCO_3)	226	190	467	554	499
Carbonate (CO_3)	0	0	0	0	0
Sulfate (SO_4)		34	71	62	150
Chloride (Cl)	75	19	79	53	53
Fluoride (F)		0.3	0.8	2	2.9
Nitrate (NO_3)		11	6.7	0.1	0.1
Total dissolved solids		373	723	657	763
Hardness as $CaCO_3$ Calcium, magnesium	176	156	383	333	409
Noncarbonate	0	60	0	0	0
Specific conductance (micromhos at 25° C)	759	491	1,110	1,060	1,190
pH	7.3	7.8	8.0		7

Table A2.1.5.2-15 (Continued)

PARAMETER	Location[b] Township, Range, Section, or Well Number		
	San Pedro Valley, Arizona		
	9S,15E,36	10S,17E,15	12S,18E,3
Date sampled (mo/yr)	8/49	6/51	8/54
Depth to water (ft)	74	215	
Silica (SiO_2)	15	28	37
Calcium (Ca)	55	42	57
Magnesium (Mg)	19	16	13
Sodium (Na) Potassium (K)		21	73
Bicarbonate (HCO_3)	322	235	304
Carbonate (CO_3)	0	0	0
Sulfate (SO_4)	13	6	80
Chloride (Cl)	30	10	12
Fluoride (F)	2	0.4	1.2
Nitrate (NO_3)	0.3	3.2	2.9
Total dissolved solids	344	243	425
Hardness as $CaCO_3$ Calcium, magnesium	215		196
Noncarbonate	0		0
Specific conductance (micromhos at 25° C)	594	396	634
pH			

Table A2.1.5.2-15 (Continued)

PARAMETER	Location[b] Township, Range, Section, or Well Number	
	Sulphur Springs Valley, Arizona	
	13S,24E,1	13S,25E,30
Date sampled (mo/yr)	5/42	7/62
Depth of water (ft)	56	
Silica (SiO_2)		
Calcium (Ca)		
Magnesium (Mg)	45	
Sodium (Na)		
Potassium (K)		
Bicarbonate (HCO_3)	107	209
Carbonate (CO_3)	0	
Sulfate (SO_4)	93	
Chloride (Cl)	115	26
Fluoride (F)		7.2
Nitrate (NO_3)	5.4	
Total dissolved solids		
Hardness as $CaCO_3$ Calcium, magnesium		34
Noncarbonate		0
Specific conductance (micromhos at 25° C)	782	440
pH		

Table A2.1.5.2-15 (Continued)

PARAMETER	Location[b] Township, Range, Section, or Well Number	
	San Simon Basin, Arizona	
	13S,30E,9	13S,30E,25
Date sampled (mo/yr)	11/40	11/40
Depth to water (ft)	48	82
Silica (SiO_2)		
Calcium (Ca)	3	8
Magnesium (Mg)	3.9	4.4
Sodium (Na)		
Potassium (K)		
Bicarbonate (HCO_3)	54	128
Carbonate (CO_3)	34	0
Sulfate (SO_4)	86	86
Chloride (Cl)	14	9
Fluoride (F)	14	4.7
Nitrate (NO_3)	0.5	1.4
Total dissolved solids	289	260
Hardness as $CaCO_3$ Calcium, magnesium	23	38
Noncarbonate		
Specific conductance (micromhos at 25° C)	465	414
pH		

Table A2.1.5.2-15 (Continued)

PARAMETER	Location[b] Township, Range, Section, or Well Number	
	Animas and Lordsburg Valleys, New Mexico	
	23S,20W,13	24S,17W,11
Date sampled (mo/yr)		
Depth to water (ft)		
Silica (SiO_2)		31
Calcium (Ca)	32	30
Magnesium (Mg)	19	13
Sodium (Na) Potassium (K)	152	45
Bicarbonate (HCO_3)	209	179
Carbonate (CO_3)	0	0
Sulfate (SO_4)	231	57
Chloride (Cl)	49	11
Fluoride (F)	1.9	1.2
Nitrate (NO_3)	2.4	3.1
Total dissolved solids	590	279
Hardness as $CaCO_3$ Calcium, magnesium	158	
Noncarbonate	0	
Specific conductance (micromhos at 25° C)	945	
pH		

Table A2.1.5.2-15 (Continued)

PARAMETER	Location[b] Township, Range, Section, or Well Number		
	Mimbres Basin, New Mexico		
	24S,7W,9	24S,9W,6	24S,11W,12
Date sampled (mo/yr)			
Depth to water (ft)			
Silica (SiO_2)	83		22
Calcium (Ca)	14	29	36
Magnesium (Mg)	4.3	7.7	6.6
Sodium (Na) Potassium (K)	115	37	278
Bicarbonate (HCO_3)	246	182	122
Carbonate (CO_3)	0		4
Sulfate (SO_4)	50	19	568
Chloride (Cl)	16	9	15
Fluoride (F)	4.4	0.6	0.8
Nitrate (NO_3)	19	2	0.6
Total dissolved solids	427	194	992
Hardness as $CaCO_3$ Calcium, magnesium	52	104	117
Noncarbonate	0	0	10
Specific conductance (micromhos at 25° C)	577	346	1,430
pH	8.1		8.3

Table A2.1.5.2-15 (Continued)

PARAMETER	Location[b] Township, Range, Section, or Well Number			
	Hueco Bolson, New Mexico and Texas			
	JL49-12-102[c] (137)	JL49-04-723[c] (138)	49-11-302[d] (143)	26S,5E,21[d] (144)
Date sampled (mo/yr)	4/36	4/36	4/36	4/36
Depth to water (ft)	273	268	314	310
Silica (SiO_2)				
Calcium (Ca)	25	35	25	24
Magnesium (Mg)	7.2	8.8	11	6.7
Sodium (Na) / Potassium (K)	65	116	99	41
Bicarbonate (HCO_3)	136	146	131	104
Carbonate (CO_3)				
Sulfate (SO_4)	48	54	83	44
Chloride (Cl)	48	139	90	28
Fluoride (F)	5.5	5.0	3.3	7.0
Nitrate (NO_3)				
Total dissolved solids	266	430	376	202
Hardness as $CaCO_3$ Calcium, magnesium	92	124	108	87
Noncarbonate				
Specific conductance (micromhos at 25° C)				
pH				

[c] Location of well numbers in Texas are identified by county, latitude/longitude grid. Alpha digits identify by county: JL, El Paso County, TJ, Midland County. Well numbers (in parenthesis) are identified on Map 2.1.5-10, Attachment 1.

[d] Wells located in New Mexico. Well No. 49-11-302 is located in New Mexico but is assigned a Texas grid number without a county designation.

Table A2.1.5.2-15 (Continued)

PARAMETER	Location[b] Township, Range, Section, or Well Number						
	Hudspeth County, Texas						
	Salt Basin Wells						
	1	2	3	4	5	6	7
Date sampled (mo/yr)			10/58		7/60	7/60	7/60
Depth of well (ft)			2,308		125	250	515
Silica (SiO_2)			11		20	19	22
Calcium (Ca)			28		270	448	145
Magnesium (Mg)			11		126	245	65
Sodium (Na) Potassium (K)			2,210		443	601	91
Bicarbonate (HCO_3)			928		264	252	278
Carbonate (CO_3)							
Sulfate (SO_4)	134	1,660	224	662	1,010	1,370	438
Chloride (Cl)	46	1,650	2,820	330	590	1,070	98
Fluoride (F)			3.6				
Nitrate (NO_3)					68	11	5.4
Total dissolved solids	678	5,320	5,760	1,680	2,660	4,090	1,000
Hardness as $CaCO_3$ Calcium, magnesium			115		1,190	2,130	630
Noncarbonate							
Specific conductance (micromhos at 25° C)			9,730		3,750	5,760	1,460
pH			7.9		6.8	7.0	7.1

Table A2.1.5.2-15 (Continued)

PARAMETER	Location[b] Township, Range, Section, or Well Number				
	Midland County (TJ), Texas				
	State Well Number				
	27-62-604	27-63-801	27-64-401	28-57-901	44-01-103
Date sampled (mo/yr)	7/74	3/67	4/75	4/74	12/71
Aquifer	Ogallala	Edwards-Trinity	Ogallala	Ogallala	Ogallala
Well depth (ft)	136	66	127		
Silica (SiO_2)	53	43	51	58	50
Calcium (Ca)	270	101	191	107	226
Magnesium (Mg)	118	11	38	54	104
Sodium (Na)	310	67	102	98	164
Bicarbonate (HCO_3)	203	340	211	229	237
Sulfate (SO_4)	820	73	192	188	600
Chloride (Cl)	560	65	338	209	359
Fluoride (F)	3.9	2.1	1.2	3.1	2.3
Nitrate (NO_3)	43	11	18	31	18
Total dissolved solids	2,278	540	1,035	861	1,639
Hardness as $CaCO_3$	1,160	300	630	490	990
Specific conductance (micromhos at 25° C)	3,000	836	1,650	1,320	2,270
pH	7.4	7.5	7.5	7.4	7.4

Table A2.1.5.2-15 (Continued)

PARAMETER	Location[b] Township, Range, Section, or Well Number				
	Midland County (TJ), Texas (Continued)				
	State Well Number				
	44-01-203	44-01-204	44-01-302	45-06-301	45-07-501
Date sampled (mo/yr)	2/67	7/74	2/67	3/67	3/67
Aquifer	Edwards-Trinity	Edwards-Trinity	Edwards-Trinity	Edwards-Trinity	Edwards-Trinity
Well depth (ft)	78	62	62		
Silica (SiO_2)	65	58	65	27	30
Calcium (Ca)	182	133	141	72	70
Magnesium (Mg)	112	74	89	10	12
Sodium (Na)	217	145	180	22	38
Bicarbonate (HCO_3)	222	207	240	237	237
Sulfate (SO_4)	680	381	520	34	66
Chloride (Cl)	342	234	274	26	46
Fluoride (F)	4.5	4.2	4.8	1.1	1.2
Nitrate (NO_3)	21	27	14	14	15
Total dissolved solids	1,732	1,158	1,405	322	403
Hardness as $CaCO_3$	920	640	720	221	245
Specific conductance (micromhos at 25° C)	2,430	1,660	2,050	520	645
pH	7.6	7.5	7.5	7.5	7.6

Table A2.1.5.2-15 (Continued)

PARAMETER	Location[b] Township, Range, Section, or Well Number				
	Midland County, Texas (Continued)				
	State Well Number				
	A-3[e]	A-11[e]	B-4[e]	C-1[e]	C-10[e]
Date sampled (mo/yr)	4/37	4/37	4/37	11/47	2/37
Aquifer					
Well depth (ft)	110	100	48	113	48
Silica (SiO_2)					
Calcium (Ca)				78	101
Magnesium (Mg)				16	44
Sodium (Na)				54[f]	162[f]
Bicarbonate (HCO_3)	122	220	268	266	316
Sulfate (SO_4)	152	72	80	68	312
Chloride (Cl)	34	56	53	48	142
Fluoride (F)					
Nitrate (NO_3)				11	
Total dissolved solids	368	370	416	457	916
Hardness as $CaCO_3$				248	432
Specific conductance (micromhos at 25° C)					
pH					

[e] Well number from Knowles (1952).

[f] Sodium plus potassium.

REFERENCES

Appendix 2.1.5.2

1. Babcock, H.M. 1974. Annual Report on Ground Water in Arizona - Spring 1972 to Spring 1973. Arizona water Commission report 7.

2. Briggs, D.C. 1969. Ground Water Conditions in the Ranegras Plain, Yuma County, Arizona. Arizona State Land Department Water Resources Report 41.

3. California Department of Water Resource. 1964. Coachella Valley Investigation Resource Bulletin No. 108.

4. California Department of Water Resources. 1966. See Williams Brothers, 1976.

5. California Department of Water Resources. 1975. California's Ground Water. California Department of Water Resources Bulletin 118.

6. California Regional Water Quality Board, L.A. Region, 1970-1975. See Williams Brothers, 1976.

7. Dennis, E.E. 1975. Maps Showing Ground-Water Conditions in the Waterman Wash Area, Maricopa and Pinal Counties, Arizona - 1975. Arizona Water Commission Hydrologic Map Series H-1.

8. Department of Water Resources, Southern District. No Date. Surface Water Analysis for Whitewater River at Whitewater Resources Agency, Los Angeles, CA.

9. Hale, W.E., L.J. Reiland, and J.P. Beverage. 1965. Characteristics of the Water Supply in New Mexico. New Mexico State Engineer Technical Report 31.

10. Leggat, E.R., M.E. Lowry, and J.W. Hood. 1963. Ground-Water Resources of the Lower Minlla Valley, Texas and New Mexico. U.S. Geological Survey Water-Supply Paper 1669-AA.

11. Metzger, D.G., O.J. Loeltz, and B. Irelan. 1973. Geohydrology of the Parker-Blythe-Cibola Area, Arizona and California. U.S. Geological Survey Professional Paper 486-G.

12. Mount, J.R., et al. 1967. Reconnaissance Investigation of the Ground-water Resources of the Colorado River Basin, Texas. Texas Water Development Report 51.

13. Reeder, H.O. 1957. Ground Water in Animas Valley, Hidalgo County, New Mexico. New Mexico State Engineer Technical Report 11.

14. Sayre, A.N. and P. Livingston. 1945. Ground-Water Resources of the El Paso Area, Texas. U.S. Geological Survey Water-Supply Paper 919.

15. Stulik, R.S. and R.L. Lowry. 1976. Maps Showing Groundwater Conditions in the Lower Hassayampa Area, Maricopa County, Arizona. Geological Survey Open File Report.

16. U.S. Geological Survey. 1970b. Surface Water Supply of the United States 1961-1965, part 10. Water Supply Paper No. 1927. U.S. Geological Survey, Washington, D.C.

Appendix 2.1.5.2 (Continued)

17. U.S. Geological Survey. 1970c. Surface Water Supply of the United States 1961-1965, part 11. U.S. Geological Survey, Washington, D.C.

18. U.S. Geololgical Survey. 1970d. Water Resources Data for California, part 1. Surface Water Records: Colorado River Basin, Southern Great Basin, and Pacific Slope Basins, excluding Central Valley. Vol. 1. Calif. Water Resources Div., Menlo Park, CA.

19. U.S. Geological Survey. 1971. Water Resources Data for California part 1. Surface Water Records: Colorado River Basin, Southern Great Basin, and Pacific Slope Basins, excluding Central Valley. Vol 1. Calif. Water Resources Div., Menlo Park, CA.

20. U.S. Geological Survey. 1972. Water Resources Data for California part 1. Surface Water Records: Colorado River Basin, Southern Great Basin, and Pacific Slope Basins, excluding Central Valley. Vol. 1. California Water Resour. Div., Menlo Park, CA.

21. U.S. Geological Survey. 1973a. Water Resources Data for California part 1. Surface Water Records: Colorado River Basin, Southern Great Basin, and Pacific Slope Basins, excluding Central Valley. Vol 1. Calif. Water Resour. Div., Menlo Park, CA.

22. U.S. Geological Survey. 1974. Water Supply Paper No. 2149. U.S. Geological Survey.

23. White, N.D. 1963. Ground-Water Conditions in the Rainbow Valley and Waterman Wash Areas, Maricopa and Pinal Counties, Arizona. U.S. Geological Water-Supply Paper 1669-F.

24. Williams Brothers Engineering Co. 1976. Environmental Impact Assessment, West Coast - Mid-Continent Pipeline. Prepared for SOHIO Transportation Co. Tulsa, OK.

APPENDIX A2.1.5.4

Water Quality Standards

Table A2.1.5.4-1

Trace Constituents[a]

Los Angeles River Basin

CONSTITUENT	Limiting Concentrations[b] (mg/l)	CONSTITUENT	Limiting Concentrations[b] (mg/l)
Arsenic	0.1	Fluoride	1.0
Barium	1.0	Iron	0.3
Boron	0.5	Lead	0.05
Cadmium	0.01	Manganese	0.05
Chromium	0.05	Mercury	0.005
Cobalt	0.2	Selenium	0.01
Copper	0.02	Silver	0.05
Cyanide	0.2	Zinc	0.1

Source: California Regional Water Quality Control Board, 1975.

[a] For surface water designated for municipal use.

[b] Readings given are maximum allowable readings.

Table A2.1.5.4-2

Mineral Quality Objectives for Surface Waters

Los Angeles River Basin

STREAM AND REACH	Objectives (mg/l) Total Dissolved Solids	Sulfate	Chloride	Nitrogen
San Gabriel River and tributaries from Firestone Boulevard to Morris Dam	750	300	150	8
Rio Hondo and tributaries above spreading grounds (approximately Santa Ana Freeway)	750	300	150	8
Los Angeles River and tributaries from Figueroa Street to Tidal Prism	1,500	350	150	8

Source: "Water Quality Control Plan-Los Angeles River Basin," Appendix, page A-7.

Table A2.1.5.4-3

Water Quality Objectives for Los Angeles River Basin Surface Waters[a]

LOCATION	Objectives (mg/l) Chloride	Filterable Residue	Hardness	Nitrogen (Organic)	Sodium	Sulfate
Santa Ana River -- Reach 4[b]						
San Gabriel Mountain streams:						
San Antonio Creek	4	200	100	4	15	25
Lytle Creek	4	200	100	4	15	25
Day Creek	4	200	100	4	15	25
Cucamonga Creek	4	200	100	4	15	25
San Timoteo streams:						
San Timoteo Creek	60	290	125	6	60	45
Oak Glen Creek	40	230	115	3	50	45
Little San Gorgonio	40	230	115	3	50	45
Prado area streams:						
Chino Creek	75	550	240	8	75	60

Source: California Regional Water Quality Control Board, 1975.

[a] Waters shall not contain suspended solids in the form of floating material, including solids, liquids, foams, and scum, in concentrations that cause nuisance or adversely affect beneficial uses. Trace constituents permissable are the same as for any inland water designated for municipal uses. Where natural turbidity is between 50 and 100 JTU (Jackson Turbidity Units), increases shall not exceed 10 JTU.

[b] From Mission Blvd Bridge to San Jacinto Fault. The river bed within these reaches shall be maintained free of any waste discharge, liquid or solid, which would adversely affect the water quality objectives of the underlying groundwaters, or, which might be washed downstream into Reach 3 and adversely affect any of the beneficial uses of those waters.

Surface Water Objectives, West Colorado River Basin

1. Color. Waters shall be free of coloration that causes nuisance or adversely affects beneficial uses.

2. Tastes and odors. Waters shall not contain taste- or odor-producing substances in concentrations that impart undesirable tastes or odors to fish flesh or other edible products of aquatic origin, or that cause nuisance or adversely affect beneficial uses.

3. Floating material. Waters shall not contain floating material, including solids, liquids, foams, and scum in concentrations that cause nuisance or adversely affect beneficial uses.

4. Suspended material. Waters shall not contain suspended material in concentrations that result in the deposition of material that causes nuisance or adversely affects beneficial uses.

5. Settleable material. Waters shall not contain substances in concentrations that result in the deposition of material that causes nuisance or adversely affects beneficial uses.

6. Oil and grease. Waters shall not contain soil, grease, wax, or other materials in concentrations that result in a visible film or coating on the surface of the water, that cause nuisance, or that otherwise adversely affect beneficial uses.

7. Biostimulatory substances. Waters shall not contain biostimulatory substances in concentrations that promote aquatic growths to the extent that such growths cause nuisance or adversely affect beneficial uses.

In addition, waste discharges shall not cause total nitrate (NO) and/or total phosphate (PO) concentrations to exceed certain levels. For example, nitrate concentrations in the east and west Colorado River Basins cannot exceed 5 mg/l. Top limits for total phosphate concentrations in the east and west Colorado River Basins are 0.06 and 0.05 mg/l, respectively.

8. Sediment. The suspended sediment load and suspended sediment discharge rate of surface waters shall not be altered in such a manner as to cause nuisance or adversely affect beneficial uses.

9. Turbidity. Waters shall be free of changes in turbidity that cause nuisance or adversely affect beneficial uses. Increases in turbidity attributable to controllable water quality factors shall not exceed the following limits: (1) where natural turbidity is between 0 and 50 JTU (Jackson turbidity units), increases shall not exceed 20 percent; (2) where natural turbidity is between 50 and 100 JTU, increases shall exceed 10 JTU; (3) where natural turbidity is greater than 100 JTU, increases shall not exceed 10 percent.

10. pH. Changes in normal ambient pH levels attributable to controllable water quality factors shall not exceed 0.5 unit, and shall not depress the receiving water pH below 6.5 units, nor raise it above 8.5 units.

11. Dissolved oxygen. As a result of controllable water quality factors, the dissolved oxygen concentration shall not be reduced below the following minimum levels at any time: waters designated "Warm" or "Sal," 5.0 mg/l; and waters designated "Cold," 7.0 mg/l.

12. Bacteria. In waters designated for contact recreation, the fecal coliform concentration based on a minimum of not less than

five samples for any 30-day period, shall not exceed a log mean of 200 to 100 ml, nor shall more than 10 percent of total samples during any 30-day period exceed 400 to 100 ml.

In waters designated for noncontact recreation and not designated for contact recreation, the average fecal coliform concentration for any 30-day period shall not exceed 2,000 to 100 ml nor shall more than ten percent of samples collected during any 30-day period exceed 4,000 to 100 ml.

13. Temperature. Waste discharges shall not cause the temperature of "Warm" interstate waters to be increased by more than 5°F.

14. Toxicity. Waters of the state shall be maintained free of toxic substances in concentrations which are toxic to, or which produce, detrimental physiological responses in human, plant, animal, or indigenous aquatic life, or which create undesirable tastes or odors in organisms utilized for human consumption.

15. Ammonia. The discharge or wastes shall not cause concentrations of deionized amonia (NH) to exceed 0.025 mg/l as nitrogen (N) in receiving waters (objective to West Colorado River Basin only).

16. Pesticides. No individual pesticide or combination of pesticides shall be present in concentrations that adversely affect beneficial uses. There shall be no increase in pesticide concentrations found in bottom sediments or aquatic life.

17. Chemical constituents. No water designated for use as domestic or municipal supply (MUN) shall contain concentrations of

chemical constituents in excess of the limits given in Tables 2.1.5.4-4, 2.1.5.4-5, and 2.1.5.4-6.

Table A2.1.5.4-4

Limiting Concentrations of Inorganic Chemicals for Colorado River Basins

CONSTITUENT	Limiting Concentration (mg/l)
Arsenic (As)	0.10
Barium (Ba)	1.0
Cadmium (Cd)	0.01
Chromium (Cr)	0.05
Cyanide (CN)	0.2
Lead (Pb)	0.05
Mercury (Hg)	0.005
Nitrate-N + Nitrite-N	10
Selenium (Se)	0.01
Chlorine (Cl)	0.003

Table A2.1.5.4-5

Limiting Fluoride Concentrations for

Colorado River Basins

AIR TEMPERATURES[a]	Fluoride Concentration (mg/l)		
	Lower	Optimum	Upper
50-54	0.9	1.2	1.7
55-58	0.8	1.1	1.5
59-64	0.8	1.0	1.3
65-71	0.7	0.9	1.2
72-79	0.7	0.8	1.0
80-81	0.6	0.7	0.8

[a] Annual average of maximum daily temperatures.

Table A2.1.5.4-6

Limiting Concentrations of Chemicals in Discharges of Wastes to Surface Waters in Colorado River Basins

CONSTITUENT	Limiting Concentration (mg/l) (Maximum)
Aluminum (Al)	0.11
Arsenic (As)	0.06
Barium (Ba)	0.55
Cadmium (Cd)	0.01
Chromium (Total Cr)	0.06
Copper (Cu)	0.06
Cyanide (CN)	0.01
Iron (Fe)	0.22
Lead (Pb)	0.06
Manganese (Mn)	0.06
Selenium (Se)	0.01
Silver (Ag)	0.01
Zinc (Zn)	0.06
Mercury (Hg)	0.01

Source: California Regional Water Quality Control Board, 1975.

Dissolved solids shall not be added in quantities found to be deleterious to established beneficial uses.

18. Radioactivity. Radionuclides shall not be present in waters in concentrations which are deleterious to human, plant, animal, or aquatic life, not that result in the accumulation of radionuclides in the food web to an extent which presents a hazard to human, plant, animal, or aquatic life.

Table A2.1.5.4-7

Mineral Quality Objectives for Groundwater in the

Los Angeles/San Gabriel Hydrographic Unit

AREA	Objectives (mg/l)			
	Total Dissolved Solids	Sulfate	Chloride	Boron
West Coast Basin	800	250	250	1.5
Central Basin	700	250	250	1.0
Puente Basin	1,000	300	150	1.0
San Gabriel Valley:				
Overall	550	150	100	1.0
Westerly portion	450	100	100	0.5
Easterly portion	600	100	100	0.5

Source: California Regional Water Quality Control Board, 1975.

Table A2.1.5.4-8

Groundwater Quality Objectives[a]

in the Santa Ana River Basin

OBJECTIVES (mg/l)	Groundwaters			
	Chino II	Colton	Bunker Hill II	San Timoteo
Chloride	15	35	20	25
Filterable residue	330	400	290	230
Hardness	180	240	160	100
Nitrate	5	3	5	3
Sodium	15	35	30	45
Sulfate	10	25	60	15

Source: California Regional Water Quality Control Board, 1975.

[a] For trace constituents see Table 2.1.5.4-15.

Table A2.1.5.4-9

Trace Constituents[a]

Santa Ana River Basin

CONSTITUENT	Limiting Concentrations (mg/l)	CONSTITUENT	Limiting Concentrations (mg/l)
Arsenic	0.1	Fluoride	1.0
Barium	1.0	Iron	0.3
Boron	0.5	Lead	0.05
Cadmium	0.01	Manganese	0.05
Chromium	0.05	Mercury	0.005
Cobalt	0.2	Selenium	0.01
Copper	0.02	Silver	0.05
Cyanide	0.2	Zinc	0.1

Source: California Regional Water Quality Control Board, 1975.

[a] For groundwater municipal use.

Table A2.1.5.4-10

Selected Chemical Groundwater Quality Objectives for

East and West Colorado River Basins

AREAS[a]	Objectives (mg/l)					
	Sulfate	Chloride	Nitrate	Fluoride	Boron	Total Dissolved Solids
Palm Springs and vicinity	50	20	5.0	0.4	.04	250
Thousand Palms and vicinity	30	15	2.5	0.8	.02	250
Palm Desert and vicinity	50	25	2.5	0.3	.10	275
Indio and vicinity	15	10	1.0	0.5	.09	200
Remaining areas in Indio subarea	100	35	2.5	1.0	.10	250
Palo Verde subarea	290	200	1.5	0.9	0.65	1,040

Source: California Regional Water Quality Control Board, 1975.

[a] All areas listed are in West Colorado River Basin except Palo Verde subarea (East Basin).

For domestic and industrial use, the standards are as follows:

1. Bacteriological quality. The fecal coliform shall not exceed a geometric mean to 1,000 to 100 ml nor shall more than 10 percent of the samples during any 30-day period exceed 2,000 to 100 ml, based upon a minimum of five samples during such period.

2. Toxic. The limits for toxic elements are shown in Table A2.1.5.4-11.

Table A2.1.5.4-11

Limits of Toxic Substances in Industrial and Domestic Uses[a]

SUBSTANCES	Limiting Concentration (mg/l)
Arsenic	0.05
Barium	1.0
Cadmium	0.01
Chromium (hexavalent)	0.05
Copper	1.
Cyanide	0.2
Mercury	0.005
Lead	0.05
Phenol	0.001
Selenium	0.01
Silver	0.05
Zinc	5.

Source:

[a] State of Arizona, surface waters.

For agricultural uses, the standards are as follows:

1. Bacteriological quality. For full body contact the fecal coliform content of recreation waters shall not exceed a geometric mean of 200 to 100 ml, nor shall more than 10 percent of the total samples during any 30-day period exceed 400 to 100 ml, based on a minimum of five samples during such period.

With partial body contact, the fecal coliform content shall not exceed a geometric mean of 1,000 to 100 ml nor shall more than 10 percent of the samples during any 30-day period exceed 2,000 to 100 ml, based on a minimum of five samples during such period.

2. pH level. The pH shall remain within the limits of 6.5 and 8.6 at all times. The maximum change permitted as a result of waste discharges shall not exceed 0.5 pH unit.

3. Temperature. Heat added to any water shall be of the lowest practical value. In no case shall heat be added in excess of that which would raise the temperature of the minimum daily flow of record for that month more than 5°F above the water or stream section under consideration; nor shall heat be added in excess of that which would raise the stream temperature above 93°F. This provision shall not apply to lakes or impoundments owned by a firm or individual for the express purpose of providing and/or receiving heat wastes.

4. Turbidity. Turbidity of the water will be maintained at the lowest practicable values possible. In no case shall turbidity in the surface waters due to the discharge of wastes exceed 50 Jackson units in warm water fishery streams or 10 Jackson units in cold water fishery streams. Nor shall discharge to warm water fishery

lakes cause turbidities to exceed 25 Jackson units, and discharge to cold water fishery lakes cause turbidities to exceed 10 Jackson units.

These standards are applicable to turbidity caused by activities including, but not limited to, construction, mining, logging, and related land uses.

5. Toxic. The limits for toxic substances are shown in Table A2.1.5.4-12.

Table A2.1.5.4-12

Limits of Toxic Substances in Agricultural Uses[a]

SUBSTANCES	Limiting Concentration (mg/l)
Arsenic	0.05
Barium	1.0
Cadmium	0.01
Chromium (hexavalent)	0.05
Copper	1.
Cyanide	0.2
Lead	0.05
Mercury	0.005
Phenol	0.001
Selenium	0.01
Silver	0.05
Zinc	5.

[a] State of Arizona, surface water.

For fish, aquatic life, and wildlife use, the standards are as follows:

1. Bacteriological quality. The fecal coliform content shall not exceed a geometric mean of 1,000 to 100 ml nor shall more than 10 percent of the samples during a 30-day period exceed 2,000 to 100 ml, based on a minimum of five samples during such period.

2. pH level. The pH shall remain within the limits of 6.5 and 8.6 at all times. The maximum change permitted as a result of waste discharges shall not exceed 0.5 pH unit.

3. Dissolved oxygen. The discharge of wastes that lower the dissolved oxygen content below 6 mg/l is prohibited where the receiving body of water is a fishery.

4. Temperature. For warm water fisheries, heat added to any warm water shall be the lowest practical value. In no case shall heat be added in excess of that amount that would raise the temperature of the minimum daily flow of record for that month more than 5°F above the monthly average of the maximum daily water temperature prevailing in the water or stream section under consideration; nor shall heat be added in excess of the amount that would raise the stream temperature above 93°F. This provision shall not apply to lakes or impoundments owned by a firm or individual for the express purpose of providing and/or receiving heat wastes.

For cold water fisheries, heat added to cold water fisheries shall be the lowest practical value. In no case shall heated wastes be discharged in the vicinity of spawning areas. In other areas, winter temperatures (November through March) shall not be raised above 55°F and summer temperatures (April through October) shall not be raised above 70°F. In both winter and summer, heat shall

not be added in excess of that amount that would raise the temperature of the minimum daily flow of record for that month more than 2°F above the monthly average of the maximum daily water temperatures prevailing in the water or stream section under consideration. These provisions shall not apply to lakes or impoundments owned by a firm or individual for the express purpose of providing cooling water and/or receiving heat wastes.

Pertaining to wildlife in areas where fisheries are not a consideration, the temperature of wastes discharged to any watercourse shall not interfere with any wildlife use, or detract from aesthetic values.

5. Turbidity. Turbidity of the water will be maintained at the lowest practicable values possible, but in no case shall turbidity in the surface waters, due to the discharge of wastes, exceed 50 Jackson units in warm water fishery streams or 10 Jackson units in cold water fishery streams. Nor shall discharge to warm water fishery lakes cause turbidities to exceed 25 Jackson units, and discharge to cold water fishery lakes cause turbidities to exceed 10 Jackson units.

These standards are applicable to turbidity caused by activities including, but not limited to, construction, mining, logging, and related land uses.

6. Toxic. Limits shall not be exceeded for the listed limits for toxic substances as shown in Table A2.1.5.4-13.

Table A2.1.5.4-13

Limits of Toxic Substances for Fish, Aquatic Life, and Wildlife Uses[a]

SUBSTANCES	Limiting Concentration (mg/l)
Arsenic	0.05
Barium	0.5
Cadmium	0.01
Chromium (Hexavalent)	0.05
Copper	0.05
Cyanide	0.10
Lead	0.05
Mercury	0.005
Phenol	0.001
Selenium I	0.01
Silver	0.05
Zinc	0.5

[a] State of Arizona, surface waters.

Table A2.1.5.4-14

Standards for Domestic and Livestock Watering Use[a]

SUBSTANCES	Limiting Concentration (mg/l)[b]
Aluminum	5.0
Arsenic	0.05
Barium	1.0
Cadmium	0.01
Chloride	250
Chromium	0.05
Cobalt	1.0
Copper	1.0
Cyanide	0.2
Iron	0.3
Fluoride	1.7
Lead	0.05
Manganese	0.2
Total Mercury	0.002
Nitrate	10.
Phenols	0.005
Selenium	0.01
Silver	0.05
Total dissolved solids	1000.
Sulfate	600.
Uranium	5.0
Vanadium	0.1

[a] State of New Mexico, for groundwater.

[b] Except where other units are used for radioactivity and pH.

Table A2.1.5.4-14 (Continued)

SUBSTANCES	Limiting Concentration (mg/l)
Organic chemicals as determined by the carbon chloroform extract method	0.7
Radioactivity Combined radium-226 and radium-228	5. pCi/l
Zinc	5.
pH	between 6 and 9

Standards for irrigation use are given in Table A2.1.5.4-15.

Table A2.1.5.4-15

Standards for Irrigation Use[a]

SUBSTANCES	Limiting Concentrations (mg/l)
Aluminum	5.0
Boron	0.75
Cobalt	0.05
Molybdenum	0.15
Nickel	0.2

[a] State of New Mexico, for groundwater.

Table A2.1.5.4-16

Texas Water Quality Standards[a]

USES AND CRITERIA	Rio Grande Basin: Rio Grande[a]	Rio Grande Basin: Pecos River[b]	Rio Grande Basin: Red Bluff Reservoir
Contact recreation		X	X
Noncontact recreation	X	X	X
Propagation of fish and wildlife	X	X	X
Domestic raw water supply	X	X	
Chloride (mg/l) avg. not to exceed	500	7,000	6,000
Sulfate (mg/l) avg. not to exceed	700	3,500	3,500
Total dissolved solids (mg/l) avg. not to exceed	1,800	15,000	15,000
Dissolved oxygen (mg/l) not less than	5.0	5.0	5.0
pH range	7.0-9.0	6.5-9.0	7.0-9.0
Fecal/(100ml)-log. avg. not more than (see Gen. Statement)	1,000	200	200
Temperature °F (see Gen. Statement)	95	92	90

Source: Texas Water Quality Board, 1976.

[a] Riverside Diversion Dam to New Mexico.

[b] County road low water crossing to Red Bluff Dam.

Table A2.1.5.4-17

State Approved Water Quality Standards for Coastal Waters

PARAMETER	California	Alaska
Dissolved oxygen	Coastal waters -- min. of 5 mg/l with additional limits on the annual mean avg. which ranges from 6 to 7 mg/l.	Class D -- Growth and Propagation of Fish and Other Aquatic Life, Including Waterfowl, Furbearers, and Other Aquatic and Semi-Aquatic Life. "Greater than 6 mg/l in Salt Water Minimum of 7 mg/l in the adult stage. Class E -- Shellfish Growth and Propagation (Natural and Commerical Growing Areas). Greater than 6 mg/l saturation in the larval stage. Greater than 5 mg/l in the adult stage.
Nitrates	Pacific Ocean Coastal Waters, Rincon Point to San Gabriel River: The only standard that might be applicable is the following narrative statement: "Other Materials: Other materials shall not be present in concentrations that would be deleterious to fish, plant or aquatic wildlife." Harbors, Marinas and Tidal Prisms in Los Angeles and Ventura Counties: The following narrative statement applies to all nutrients including nitrates: "Nutrients: Nutrients of other than natural origin shall not be present in concentrations capable of causing proliferation of plankton or other undesirable biotic growths.	There is no specific criteria and no narrative statement directed at the limitation of such nutrients as nitrate. Unless the toxic material standards or the taste and odor could be applied to nitrate problems there is only one other possibility. That is the following Policy Statement of the State of Alaska: Alaska Statutes Title 46, 05, 010: "It is the public policy of the state to maintain reasonable standards of purity of the waters of the state consistent with public health and public enjoyment, the propagation and protection of fish and wildlife, including birds, mammals and other terrestrial and aquatic life, and the industrial development of the state, and to require the use of all known available and reasonable methods to prevent and control the pollution of the waters of the state."

Table A2.1.5.4-17 (Continued)

PARAMETER	California	Alaska
Phosphates	Pacific Ocean Coastal Waters, Rincon Point to San Gabriel River: The only standard that might be applicable is the following narrative statement: "Other Materials: Other materials shall not be present in concentrations that would be deleterious to fish, plant or aquatic wildlife." Harbors, Marinas and Tidal Prisms in Los Angeles and Ventura Counties: The following narrative statement does not specifically mention phosphates but applies to all nutrients of which phosphates are one of the important ones. Nutrients: Nutrients of other than natural origin shall not be present in concentrations capable of causing proliferation of plankton or other undesirable biotic growths.	There is no specific criteria or narrative statement directed at the limitation of such nutrients as phosphate. Unless the toxic material standards or the taste and odor standards could be applied to phosphate problems there is only one other possibility. That is the following Policy Statement of the State of Alaska: Alaska Statutes Title 46, Chapter 05, Section 46, 05, 010: "It is the public policy of the state to maintain reasonable standards of purity of the waters of the state consistent with public health and public enjoyment, the propagation and protection of fish and wildlife, including birds, mammals, and other terrestrial amd aquatic life and the industrial development of the state, and to require the use of all known available and reasonable methods to prevent and control the pollution of the waters of the state."
Acidity/ alkalinity	Pacific Ocean Coastal (Rincon Point-San Gabriel River) 7.0-8.5 Pacific Ocean Coastal Waters 7.0-8.6	Swimming 6.5-8.5 F&WL 7.8-8.5 Saltwater 6.5-8.5 Freshwater Shellfish 7.8-8.5
Settleable solids	Generally limited to concentrations that would adversely affect the aquatic environment.	Class D -- Fish & Wildlife Propagation. No appreciable deposition which will adversely affect fish spawning and habitat. Class E -- Shellfish Growth and Propagation. No appreciable deposition which adversely affects growth and propagation.

Table A2.1.5.4-17 (Continued)

PARAMETER	California	Alaska
Oil	California -- (Varies from basin to basin, but generally of following type): The waters shall be free from floating debris, oil, grease, scum, or other carried or floating materials.	Class D -- None alone or in combination with other substances of wastes which would make receiving water unfit or unsafe for the use indicated, except that no waste oils, tars, greases or animal fats are permitted. Class E -- No visible evidence of wastes. Less than acute or chronic problem levels as revealed by bioassay or other appropriate methods.

Source: Tetra Tech, Inc., 1977. Environmental Assessment Report, Crude Oil Transportation System: Valdez, Alaska, to Long Beach, California. Prepared for U.S. Army Corps of Engineers, Los Angeles.

APPENDIX A2.1.8.1

Birds of the Southern California Bight Areas

Table A2.1.8.1-1

Birds of the Southern California Bight -- Coastal and Offshore Regions

SPECIES	Pelagic	Littoral	Bays
Common loon *Gavia immer*	FLR[a]	FLR	FLR
Arctic loon *Gavia arctica*	FLR	FLR	FLR
Red-throated loon *Gavia stellata*	FLR	FLR	FLR
Red-necked grebe *Podiceps grisegena*		F	F
Horned grebe *Podiceps auritus*		FR	F
Eared grebe *Podiceps caspicus*		F	F
Western grebe *Aechmorphorus occidentalis*		F	F
Pied-billed grebe *Podilymbus podiceps*		X	F
Black-footed albatross *Diomedia nigripes*	F		
Fulmar *Fulmarus glacialis*	F	F	
Pink-footed shearwater *Puffinus creatopus*	FLR		
Flesh-footed shearwater *Puffinus carneipes*	FLR		
Sooty shearwater *Puffinus griseus*	FLR	F	
Slender-billed shearwater	FLR		
Manx shearwater *Pufinus puffinus*	FLR		
Fork-tailed petrel *Oceanodroma furcata*	F		

Source: Bender, et al., 1974.

[a] F = feeding, L = loafing, R = roosting, N = nesting, X = unknown.

Table A2.1.8.1-1 (Continued)

SPECIES	Pelagic	Littoral	Bays
Leach's petrel *Oceanodroma leucorhoa*	F		
Ashy petrel *Oceandroma homochroa*	F		
Black petrel *Loomelania melania*	F		
Red-billed tropicbird *Phaethon aethereus*	F		
White pelican *Pelecanus erythrorhynchos*		X	X
Brown pelican *Pelecanus occidentalis*	F	F	F
Double-crested cormorant *Phalacrocorax auritus*	F	F	F
Brandt's cormorant *Phalacrocorax penicillatus*	F	F	
Pelagic cormorant *Phalacrocorax pelagicus*	F	F	
Great blue heron *Ardea herodias*		F	
Whistling swan *Olor columbianus*			X
Brant *Branta bernicla*		X	X
Snow goose *Chen caerulescens*			LR
Mallard *Anas platyrhynchos*			X
Pintail *Anas acuta*			X
Green-winged teal *Anas crecca*		X	X
American widgeon *Mareca americana*			LR
Shoveler *Spatula clypeata*			LR
Redhead *Aythya americana*			LR
Canvasback *Aythya valisineria*			LR

Table A2.1.8.1-1 (Continued)

SPECIES	Pelagic	Littoral	Bays
Greater scaup *Aythya marila*		F	FL
Lesser scaup *Aythya affinis*		F	FL
Common goldeneye *Bucephala clangula*			F
Bufflehead *Bucephala albeola*		F	F
Oldsquaw *Clangula hyemalis*		F	F
White-winged scoter *Melanitta fusca*		FLR	FLR
Surf scoter *Melanitta perspicillata*		FLR	FLR
Black scoter *Oidemia nigra*		FLR	FLR
Ruddy duck *Oxyura jamaicensis*		X	FLR
Common merganser *Mergus merganser*		F	F
Red-breasted merganser *Mergus serrator*		F	F
Osprey *Pandion haliaetus*			F
American coot *Fulica americana*			X
Red phalarope *Phalaropus fulicarius*	F	F	F
Wilson's phalarope *Steganopus tricolor*			F
Northern phalarope *Lobipes lobatus*	F	F	F
Pomerine jaeger *Stercorarius pomarinus*	F		F
Parasitic jaeger *Stercorarius parasiticus*	F	F	
Glaucous-winged gull *Larus hyperboreus*		F	F
Western gull *Larus occidentalis*	X	X	

Table A2.1.8.1-1 (Continued)

SPECIES	Pelagic	Littoral	Bays
Herring gull Larus argentatus		X	
Thayer's gull Larus thayeri		X	
California gull Larus californicus	X	F	F
Ring-billed gull Larus delamarensis		X	X
Mew gull Larus canus		F	F
Bonaparte's gull Larus philadelphia	X	F	F
Heermann's gull Larus minitus	F	FL	
Black-legged kittiwake Rissa tridactyla	F	F	
Sabine's gull Xema sabini	F		
Forster's tern Sterna foristeri		F	F
Common tern Sterna hirundo	F	F	
Arctic tern Sterna paradisaea	F		
Least tern Sterna albifrons		F	F
Royal tern Thalasseus maximus		F	F
Elegant tern Thalasseus maximus		F	F
Caspian tern Hydroprogne caspia		F	F
Common murre Uria aalge	FLR	FLR	
Pigeon guillemot Cepphus columba	F	F	
Xantus's murrelet Endomychura hypoleuca	F	F	
Craveri's murrelet Endomychura craveri	F	F	

Table A2.1.8.1-1 (Continued)

SPECIES	Pelagic	Littoral	Bays
Ancient murrelet *Synthiliboramphus antiquua*	F	F	
Cassin's auklet *Ptychoramphus aleuticus*	F	F	
Rhinoceros auklet *Cerorhinca monocerata*	F	F	
Tufted puffin *Lunda cirrhata*	F	F	
Belted kingfisher *Megaceryle alcyon*			F

In addition to the species tabulated above, the following birds may use the ocean waters of the study area occasionally or irregularly; some are usually found in other habitats (see species accounts for more detail): yellow-billed loon, *Gavia adamsii*; short-tailed albatross, *Diomedia albatrus*; Laysan albatross, *Diomedia immutabilis*; New Zealand shearwater, *Puffinus bulleri*; short-tailed shearwater, *Puffinus tenuirostris*; Harcourt's petrel, *Loomelania melania*; least petrel, *Halocyptena microsoma*; Wilson's petrel, *Oceanites oceanicus*; white-tailed tropicbird, *Phaethon lepturus*; blue-footed booby, *Sula nebouxii*; brown booby, *Sula leucogaster*; Magnificent frigatebird, *Fregata magnificens*; white-fronted goose, *Anser albifrons*; European widgeon, *Mareca penelope*; Barrow's goldeneye, *Bucephala islandica*; oldsquaw, *Clangula hyemalis*; harlequin duck, *Histrionicus histrionicus*; peregrine falcon, *Falco peregrinus*; purple gallinule, *Porphyrula martinica*; rock sandpiper, *Erolia ptilocnemis*; long-tailed jaeger, *Stercorarius longicaudus*; skua, *Catharacta skua*; glaucous gull, *Larus hyperboreus*; black-headed gull, *Rynchops nigra*; laughing gull, *Larus atricilla*; Franklin's gull, *Larus pipixcan*; little gull, *Larus minitus*; black tern, *Chlidonias niger*; black skimmer, *Rynchops nigra*; marbled murrelet, *Brachyramphus marmoratus*; Kittlitz's murrelet, *Brachyramphus brevirostria*; horned puffin, *Fratercula corniculata*.

Table A2.1.8.1-2

Birds of the Southern California Bight -- Ocean Shoreline

SPECIES	Rocky shore	Sandy beach	Sea cliffs
Brown pelican *Pelecanus occidentalis*	LR[a]		NLR
Double-crested cormorant *Phalacrocorax auritus*	LR		NLR
Brandt's cormorant *Phalacrocorax penicillatus*	LR		NLR
Pelagic cormorant *Phalacrocorax pelagicus*			NLR
Surf scoter *Melanitia perspicillata*	F		
Black scoter *Oidemia nigra*	F		
Turkey vulture *Cathartes aura*	F	F	
Red-tailed hawk *Buteo jamaicensis*			N
Peregrine falcon *Falco peregrinus*	F	F	LR
American oystercatcher *Haematopus palliatus*	FN	F	
Black oystercatcher *Haematopus bachmani*	FN		
Semipalmated plover *Charadrius semipalmatus*		F	
Snowy plover *Charadrius alexandrinus*		FLRN	
Black-bellied plover *Charadrius squat*		F	
Surfbird *Aphriza virgata*	FLR		
Ruddy turnstone *Arenaria interpres*	FLR		

Source: Bender et al., 1974.

[a] F = feeding, N = nesting, L = loafing, R = roosting, X = unknown.

Table A2.1.8.1-2 (Continued)

SPECIES	Rocky shore	Sandy beach	Sea cliffs
Black turnstone *Arenaria melanocephala*	FLR		
Long-billed curlew *Numenius americanus*		F	
Whimbrel *Numenius phaeopus*	F	F	
Spotted sandpiper *Actitus macularia*	F		
Wandering tattler *Heteroscelus incanum*	FLR		
Willet *Catoptrophorus semipalmatus*		F	
Greater yellowlegs *Totanus melanoleucus*		F	
Knot *Calidris canutus*		F	
Least sandpiper *Erolia minutilla*		F	
Dunlin *Erolia alpina*		F	
Short-billed dowitcher *Limnodromus griseus*		F	
Long-billed dowitcher *Limnodromus scolopaceus*		F	
Western sandpiper *Ereunetes mauri*		F	
Marbled godwit *Limosa fedoa*		F	
Sanderling *Crocethia alba*		F	
Glaucous-winged gull *Larus hyperboreus*		FL	
Western gull *Larus occidentalis*		FL	
Herring gull *Larus argentatus*		FL	
Thayer's gull *Larus thayeri*		FL	

Table A2.1.8.1-2 (Continued)

SPECIES	Rocky shore	Sandy beach	Sea cliffs
California gull Larus californicus		FL	
Ring-billed gull Larus delawarensis		FL	
Mew gull Larus canus		FL	
Heermann's gull Larus minitus		FL	
Forster's tern Sterna forsteri		L	
Common tern Sterna hirundo		L	
Least tern Sterna albifons		NLR	
Elegant tern Thalasseus elegans		L	
Caspian tern Hydroprogne caspia		L	
Pigeon guillemot Cepphus columba	N		N
Xantus' murrelet Endomychura hypoleuca	N		N
Rock dove Columbia livia		F	N
Ground dove Colymbigalla passarina		F	
White-throated swift Aeronaytes saxatalis			NR
Black phoebe Sayornis nigricans			N
Barn swallow Riparia riparia			N
Common raven Corvus corax	F	F	N
Canyon wren Catherpus mexicanus			FN

Table A2.1.8.1-2 (Continued)

SPECIES	Rocky shore	Sandy beach	Sea cliffs
Rock wren *Salpinctes obseletus*			FN
Sage sparrow *Amphispiza delli*		F	

In addition to the species tabulated above, the following birds may use the ocean shoreline occasionally or irregularly, though they are usually found in other habitats (see species accounts for more detail): common loon, *Gavia immer*; great blue heron, *Ardea herodias*; oldsquaw, *Clangula hyemalis*; harlequin duck, *Histronicus histronicus*; bald eagle, *Haliacetus leucocephalus*; prairie falcon, *Falco mexicanus*; Wilson's plover, *Charadrius wilsonia*; American golden plover, *Pluvialis dominica*; piping plover, *Charadrius melodus*; Baird's sandpiper, *Erolia minutilla*; stilt sandpiper, *Micropalama himantopus*; buff-breasted sandpiper, *Tryngites subruficollis*; red phalarope, *Phalaropus fulicarius*; laughing gull, *Larus atricilla*; Franklin's gull, *Larus pipixcan*; little gull, *Larus minitus*; black tern, *Chlidonias niger*.

Table A2.1.8.1-3

Birds of the Southern California Bight -- Saltmarshes and Estuaries

SPECIES	Channels and open water	Mud flats	Vegetation
Eared grebe *Podiceps caspicus*	FLR[a]		
Western grebe *Aechmophorus occidentalis*	FLR		
Pied-billed grebe *Podilymbus podiceps*	FLR		
White pelican *Pelecanus erythrorhynchos*	F	LR	
Brown pelican *Pelecanus occidentalis*	F	LR	
Double-crested cormorant *Phalacrocorax auritus*	F	L	
Great blue heron *Ardea herodias*	F		FNLR
Common egret *Casmerodius albus*	F	F	F
Snowy egret *Leucophoyx thula*	F	F	F
Black-crowned night heron *Nycticorax nycticorax*		F	FLR
Least bittern *Ixobrychus exilis*			FLR
American bittern *Botaurus lentiginosus*			FLR
Whistling swan *Olor columbianus*	F	LR	
Canada goose *Branta canadensis*	F	F	F
White-fronted goose *Anser albifrons*	F		
Snow goose *Chen caerulescens*	LR		F

Source: Bender et al., 1974.

[a] F = feeding, N = nesting, L = loafing, R = roosting, X = unknown.

Table A2.1.8.1-3 (Continued)

SPECIES	Channels and open water	Mud flats	Vegetation
Mallard *Anas platyrhynchos*	X	X	
Gadwall *Anas strepera*	X	X	
Pintail *Anas acuta*	X	X	
Green-winged teal *Anas crecca*	X	X	
Blue-winged teal *Anas discors*	X	X	
Cinnamon teal *Anas cyanoptera*	X	X	
European widgeon *Mareca penelope*	X	X	
American widgeon *Mareca americana*	X	X	
Shoveler *Spatula clypeata*	X	X	
Canvasback *Aythya valisineria*	X		
Greater scaup *Aythya marila*	X		
Lesser scaup *Aythya affinis*	X		
Common goldeneye *Bucephala clangula*	X		
Bufflehead	X		
Surf scoter *Melantia perspicillata*	X		
Ruddy duck *Oxyura jamaicensis*	X		
Common merganser *Mergus merganser*	X		
Red-breasted merganser *Mergus serrator*	X		
Turkey vulture *Cathartes aura*			F
White-tailed kite *Elanus leucurus*			F

Table A2.1.8.1-3 (Continued)

SPECIES	Channels and open water	Mud flats	Vegetation
Red-tailed hawk Buteo jamaicensis			F
Marsh hawk Circus cyaneus			F
Osprey Pandion haliaetus	F		
Peregrine falcon Falco peregrinus		F	F
Clapper rail Rallus longirostris		F	FLRN
Virginia rail Rallus limicola			FLR
Sora Porzana carolina		F	FLR
Black rail Laterallus jamaicensis			FLR
American coot Fulica americana	X	X	X
Semiplamated plover Charadrius semipalmatus		X	
Killdeer Charadrius vociferus		X	
Black-bellied plover Squatarola squatarola		X	X
Ruddy turnstone Arenaria melanoccphala		X	
Long-billed curlew Numenius americanus		X	X
Whimbrel Numenius phaeopus		X	X
Willet Catoptrophorus semipalmatus		X	X
Greater yellowlegs Totanus melanoleucus		X	
Lesser yellowlegs Totanus flavipes		X	
Knot Calidris canutus		X	

Table A2.1.8.1-3 (Continued)

SPECIES	Channels and open water	Mud flats	Vegetation
Pectoral sandpiper *Erolia melanotos*			X
Least sandpiper *Erolia minutilla*		X	
Dunlin *Erolia alpina*		X	
Short-billed dowitcher *Limnodromus griseus*		X	X
Long-billed dowitcher *Limnodromus scolopaceus*		X	
Western sandpiper *Ereunetes mauri*		X	
Marbled godwit *Limosa fedoa*		X	X
Sanderling *Crocethia alba*		X	
American avocet *Recurvirostra americana*		X	N
Black-necked stilt *Himantopus himantopus*		X	N
Wilson's phalarope *Steganopus tricolor*		F	F
Western gull *Larus occidentalis*		X	
California gull *Larus californicus*		X	
Ring-billed gull *Larus delwarensis*		X	
Bonaparte's gull *Larus philadelphia*	X	X	
Forster's tern *Sterna forsteri*	F	LR	
Least tern *Sterna albifrons*	F	L	
Royal tern *Thalasseus maximus*	F	LR	
Elegant tern *Thalasseus elegans*	F	LR	

Table A2.1.8.1-3 (Continued)

SPECIES	Channels and open water	Mud flats	Vegetation
Caspian tern *Hydroprogne caspia*	F	LR	
Short-eard owl *Asio flammeus*		F	FR
Belted kingfisher *Megaceryle alcyon*	F		
Long-billed marsh wren *Telmatodytes dalustris*			X
Yellowthroat *Geothalypis tricaas*			X
Western meadowlark *Sturnella neglecta*			R
Savannah sparrow *Passerculus sandwichensis*			FNR

In addition to the species tabulated above, the following birds may use the tidal areas occasionally or irregularly, though they are usually found in other habitats (see species accounts for greater detail): little blue heron, *Florida caerulea*; reddish egret, *Dichromanassa rufescens*; Louisiana heron, *Hydranassa tricolor*; wood stork, *Mycteria americana*; roseate spoonbill, *Ajaja ajaja*; emperor goose, *Philacte canagica*; Ross' goose, *Chen rossii*; Barrow's goldeneye; Harlequin duck, *Histrionicus histrionicus*; hooded merganser, *Lophodytes cucullatus*; bald eagle, *Haliaeetus leucocephalus*; yellow rail, *Coturnicops noveboraceusis*; American golden plover, *Pluvialis dominica*; sharptailed sandpiper, *Erolia acuminata*; Baird's sandpiper, *Erolia bairdii*; stilt sandpiper, *Micropalama himantopus*; ruff, *Philomachus pugnax*; sharp-tailed sparrow *Ammospiza caudacuta*.

REFERENCES

Appendix 2.1.8.1-1

1. Bender, K.E., C.T. Collins, and S.L. Warter. 1974. A Summary of Knowledge of the Southern California Coastal Zone, Chapter 13, Marine and Shore Birds. Southern Calif. Ocean Studies Consortium. Dominguez Hills, Calif.

APPENDIX A2.1.8.1.3

Zooplankton and Marine Fish, Los Angeles-Long Beach Harbors

Table A2.1.8.1.3-1

Zooplankton Species, Los Angeles-Long Beach Harbors

SCIENTIFIC NAME Common Name	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
CNIDARIA												
Hydromedusae, unid.												
hydroid medusa	X	X	X	X	X		X	X	X	X	X	X
Obalis sp.												
hydroid	X			X	X	X	X		X	X	X	
Siphonophora, unid.												
pelagic hydrozoa	X		X	X	X		X					X
CTENOPHORA												
Pleurobrachia sp.												
comb jelly	X				X		X					
ANNELIDA												
Autolytus sp., juvenile												
polychaete worm							X			X	X	X
Magelona sp.												
polychaete worm				X	X		X					
Polychaeta, juvenile, unid.												
polychaete worm	X	X	X	X	X	X	X	X	X	X	X	X
Polychaeta, larvae, unid.												
polychaete worm	X	X	X	X	X	X	X	X	X	X	X	X
Polydora sp., juvenile												
polychaete worm							X	X				
Polynoidae larvae												
polychaete worm										X		
Polynoidae juvenile												
polychaete worm							X	X	X	X	X	X
Spionidae, juvenile												
polychaete worm		X	X	X	X		X	X	X	X	X	X
Tomopteris sp.												
polychaete worm				X								

Source: Environmental Quality Analysts (EQA) and Marine Biological Consultants, Inc. (MBC), 1975.

Table A2.1.8.1.3-1 (Continued)

SCIENTIFIC NAME Common Name	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
worm tubes, unid.												
polychaete tube						X						
ARTHROPODA												
CRUSTACEA												
BRANCHIOPODA												
CLADOCERA												
Evadne nordmanni												
cladoceran	X	X	X	X	X	X	X	X	X	X	X	X
E. spinifera												
cladoceran		X	X			X	X		X	X	X	X
E. tergestina												
cladoceran			X	X		X	X	X				
Penilla avirostris												
cladoceran								X			X	X
Podon polyphemoides												
cladoceran	X	X	X	X	X	X	X	X	X	X	X	X
OSTRACODA												
Conchoecia sp.												
seed shrimp	X	X	X	X	X					X	X	
Cylindroleberis mariae												
seed shrimp						X		X				
Cypris sp.												
seed shrimp										X	X	X
COPEPODA												
CYCLOPOIDA												
Clausidium sp.												
cyclopoid copepod							X					
Corycaeus anglicus												
cyclopoid copepod	X	X	X	X	X	X	X	X	X	X	X	X
C. giesbrechti												
cyclopoid copepod	X	X	X	X	X	X	X	X	X	X	X	
Corycaeus sp.												
cyclopoid copepod				X	X		X					

Table A2.1.8.1.3-1 (Continued)

SCIENTIFIC NAME Common Name	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Conaea rapax												
cyclopoid copepod			X									
Cyclopoida, A, unid.												
cyclopoid copepod	X	X	X	X	X	X	X	X	X	X	X	X
Cyclopoida, unid.												
cyclopoid copepod		X		X	X		X	X	X	X	X	X
Hemicyclops thysanotus												
cyclopoid copepod								X		X		
Oithona helgolandica												
cyclopoid copepod	X	X	X	X	X	X	X	X	X	X	X	X
O. nana												
cyclopoid copepod												X
O. oculata												
cyclopoid copepod	X	X	X	X	X	X	X	X	X	X	X	X
O. plumifera												
cyclopoid copepod	X	X	X	X	X	X						
O. spinirostris												
cyclopoid copepod	X			X	X	X	X	X	X	X	X	X
Oncaea conifera												
cyclopoid copepod	X	X	X	X	X	X	X				X	
O. dentipes												
cyclopoid copepod										X	X	
O. media												
cyclopoid copepod			X	X	X	X	X	X	X	X	X	X
O. similis												
cyclopoid copepod										X		
Oncaea sp.												
cyclopoid copepod								X		X		X
HARPACTICOIDA												
Alteutha sp.												
harpacticoid copepod		X										
Ameira sp.												
harpacticoid copepod		X										
Diosaccidae, unid.												
harpacticoid copepod								X				

Table A2.1.8.1.3-1 (Continued)

SCIENTIFIC NAME Common Name	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Euterpina acutifrons												
harpacticoid copepod	X	X	X	X	X	X	X	X	X	X	X	X
Harpacticoida, unid.												
harpacticoid copepod	X	X	X	X	X	X	X	X	X	X	X	X
Harpacticus sp.												
harpacticoid copepod	X	X		X								
Lauphontidae, unid.												
harpacticoid copepod	X											
Microsetella norvegica												
harpacticoid copepod				X	X	X	X	X	X	X	X	
M. rosea												
harpacticoid copepod		X	X	X	X	X	X	X		X	X	
Pseudobradya sp.												
harpacticoid copepod		X										
Rhynchothalestris sp.												
harpacticoid copepod								X	X	X	X	X
Thaumaleus sp.												
harpacticoid copepod									X			
Tisbe furcata												
harpacticoid copepod	X	X	X									
Tisbe sp.												
harpacticoid copepod		X										
MONSTRILLOIDA												
Monstrillidae, unid.												
copepod		X										
CALIGOIDA												
Caligoida, unid.												
copepod				X				X		X		
CALANOIDA												
Acartia clausi												
calanoid copepod	X		X	X	X							
A. dana												
calanoid copepod	X											

Table A2.1.8.1.3-1 (Continued)

SCIENTIFIC NAME Common Name	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
A. tonsa calanoid copepod	X	X	X	X	X	X	X	X	X	X	X	X
Calanoida, unid. calanoid copepod								X				
Calanus pacificus calanoid copepod	X	X	X	X	X	X	X	X	X	X		X
Calanoid copepodite, unid. calanoid copepod				X	X							
Calanus tenuicornis calanoid copepod				X								
Calocaianus styliremis calanoid copepod				X	X	X	X		X	X	X	X
Clausocalanus arcuicornis calanoid copepod		X		X	X	X	X					
C. farrani calanoid copepod												X
C. furcatus calanoid copepod										X	X	
C. parapergena calanoid copepod				X			X	X	X		X	X
Clausocalanus sp. calanoid copepod						X			X			
Ctenocaianus vanus calanoid copepod				X	X	X	X					
Ischnocalanus tenuis calanoid copepod										X		
Labidocera jollae calanoid copepod						X	X					
L. trispinosa calanoid copepod	X	X	X	X	X	X	X	X	X	X	X	X
Lucicutia flavicornis calanoid copepod			X	X	X		X			X		
Metridia lucens calanoid copepod	X	X	X				X		X	X	X	
Paracalanus parvus calanoid copepod	X	X	X	X	X		X	X	X	X	X	X

Table A2.1.8.1.3-1 (Continued)

SCIENTIFIC NAME Common Name	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Pontellopsis occidentalis												
calanoid copepod		X										
Pseudodiaptomus euryhalinus												
calanoid copepod									X		X	X
Pseudocyclops sp.												
calanoid copepod									X			X
Pleuromamma borealis												
calanoid copepod			X				X			X		
Rhincalanus nasutus												
calanoid copepod		X	X	X			X					
Rhincalanus sp.												
calanoid copepod		X										
Tortanus discaudatus												
calanoid copepod		X	X	X	X	X	X				X	X
Copepoda, nauplius, unid.												
copepod larvae	X	X	X	X	X	X	X	X	X	X	X	X
CIRRIPEDIA												
Cirripedia, cypris larvae, unid.												
barnacle larvae	X	X	X	X	X	X	X	X	X	X	X	X
Cirripedia, nauplius larvae, unid.												
barnacle larvae	X	X	X	X	X	X	X	X	X	X	X	X
MALACOSTRACA												
MYSIDACEA												
Acanthomysis macropsis												
fairy shrimp	X	X	X	X	X	X	X	X	X	X	X	X
Mysidacea, unid.												
fairy shrimp									X			
Neomysis rayii												
fairy shrimp			X	X	X							
N. kadiakensis												
fairy shrimp				X	X	X						
CUMACEA												
Cumacea, unid.												

Table A2.1.8.1.3-1 (Continued)

SCIENTIFIC NAME Common Name	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
cumacean									X			
Cumella sp. A												
cuamcean									X			
Cumella sp.												
cumacean									X			
Cyclaspis nubila												
cumacean									X			
Lampropidae, unid.												
cumacean						X						
TANAIDACEA												
Anatanais normani												
cheliferan							X					
ISOPODA												
Gnathia sp.												
isopod												X
Isopoda, unid.												
isopod		X		X	X	X	X	X		X		
Valvifora, unid.												
isopod											X	
AMPHIPODA												
Corophium sp.												
amphipod								X				
Ericthonius brasiliensis												
amphipod									X			
Gammaridea, juvenile, unid.												
amphipod			X	X		X	X	X		X		X
Stenothoidae, unid.												
amphipod												X
CAPRELLIDEA												
Caprella californica												
skeleton shrimp		X								X		
Caprella sp.												

Table A2.1.8.1.3-1 (Continued)

SCIENTIFIC NAME Common Name	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
skeleton shrimp								X			X	
Mayerella sp. A												
skeleton shrimp										X		
EUPHAUSIACEA												
Ehphausiacea calyptopis												
krill							X					
Euphausiacea, furcilla												
krill		X	X	X			X					
Euphausiacea, juvenile												
krill		X	X	X						X		
DECAPODA												
Alpheus, zoea, unid.												
shrimp zoea				X	X	X	X	X	X	X	X	
Crangon, zoea, unid.												
shrimp zoea		X	X	X	X		X					
Hippolytidae, zoea B												
shrimp							X					
Hippolytidae, zoea, unid.												
shrimp zoea		X		X	X	X	X	X	X	X	X	
Pandalidae, zoea, unid.												
shrimp zoea					X							
Pandalus, zoea												
shrimp zoea			X									
Spirontocaris zoea A												
shrimp	X						X		X		X	X
Spirontocaris, zoea, unid.												
shrimp zoea		X	X	X	X	X	X	X	X	X		
ANOMURA												
Callianassa, zoea, unid.												
shrimp zoea	X	X	X	X	X	X	X	X	X	X	X	X
Emerita analoga zoea												
sand crab				X								
Naushonia zoea												

Table A2.1.8.1.3-1 (Continued)

SCIENTIFIC NAME Common Name	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
mud shrimp					X		X	X	X	X		
Pachycheies rudis												
porcelain crab		X	X									
Paguridae, glaucothoe, unid.												
hermit crab					X							
Paguridae, zoea, unid.												
hermit crab zoea			X	X	X		X					
Pagurus, zoea, unid.												
hermit crab zoea			X	X			X					
Porcellanidae, zoea, unid.												
porcelain crab zoea			X	X		X	X					
BRACHYURA												
Brachyura, megalops, unid.												
crab				X								
Cancer, megalops, unid.												
hermit crab				X								X
Cancer, zoea, unid.												
hermit crab	X	X	X	X	X	X	X	X			X	X
Inachinae zoea												
crab zoea							X	X	X	X	X	X
Lophopanopeus bellus bellus, zoea												
crab zoea					X	X	X	X	X	X		
L. bellus diegensis, zoea												
crab zoea						X						
Pachycheles sp. zoea												
porcelain crab					X							
Pachygrapsus crassipes, zoea												
crab zoea				X	X	X	X	X	X			
Pinnixa franciscana												
crab zoea					X							
Pinnixa, zoea, unid.												
pea crab zoea	X	X	X	X	X	X	X	X	X	X	X	X
Pinnixa, megalops, unid.												
pea crab zoea				X								
Pinnotheridae, megalops, unid.												

Table A2.1.8.1.3-1 (Continued)

SCIENTIFIC NAME Common Name	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
pea crab zoea				X								
Pinnotheridae, zoea, unid.												
pea crab zoea		X	X	X	X		X				X	
Pisinae, unid.												
crab							X					
Portunus xantusii, zoea												
pea crab zoea									X			
MOLLUSCA												
GASTROPODA												
Gastropoda, veliger, unid.												
snail veliger	X	X	X	X	X	X	X	X	X	X	X	X
PELECYPODA												
Pelecypoda, veliger, unid.												
clam veliger	X	X	X	X	X	X	X	X	X	X	X	X
PHORONIDA												
Actinotroch larvae, unid.												
phoronid larvae		X	X	X	X		X	X	X	X	X	X
ECTOPROCTA												
Cyphonaute larvae, unid.												
cyphonaute	X	X	X	X	X	X	X	X	X	X	X	X
ECHINODERMATA												
Echinopluteus, unid.												
echinoid larvae											X	
CHAETOGNATHA												
Sagitta bipunctata												
arrow worm				X			X					
S. euneritica												
arrow worm	X		X	X	X	X	X	X	X	X	X	X
Sagitta sp.												
arrow worm	X	X							X			

Table A2.1.8.1.3-1 (Continued)

SCIENTIFIC NAME Common Name	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
CHORDATA												
UROCHORDATA												
ASCIDIACEA												
Tadpole larvae, unid. tadpole larvae	X	X	X		X		X	X	X	X	X	X
LARVACEA												
Larvacea, unid. pelagic tunicate											X	
Olkopleura sp. pelagic tunicate	X	X	X	X	X	X	X	X	X	X	X	X
VERTEBRATA												
OSTEICHTHYES												
Engraulis mordax, egg northern anchovy		X	X		X	X	X					
Engraulis mordax, larvae northern anchovy				X		X	X					
Pisces, egg, unid. fish egg	X	X	X	X	X	X	X	X	X	X	X	
Pisces, larvae, unid fish larvae	X	X	X	X	X		X				X	X

Table A2.1.8.1.3-2

Principal Marine Fish Found in Los Angeles-Long Beach Harbors

COMMON NAME *Genus Species*	Coastal Range	Coastal Range in Region or State	Abundance
Sixgill shark *Hexanchus griseus*	Northern Br. Col. to Todos Santos Bay, Baja California	Throughout state	Common
Sevengill shark *Notorynchus maculatus*	Northern Br. Col. to Chile, S.A.	Throughout state	Common
Hornshark *Heterodontus francisci*	Monterey Bay to Gulf of California	Throughout region	Common
Thresher shark *Alopias vulpinus*	Strait of Juan de Fuca to central Baja California	Throughout state	Common
White shark *Carcharodon carcharias*	Alaska to Chile, S.A.	Throughout state	Common
Basking shark *Cetorhinus maximus*	Alaska to the Gulf of California	Throughout state	Common
Salmon shark *Lamna ditropis*	Alaska to Point Dume, California	North of Point Dume	Uncommon
Swell shark *Cephaloscyllium ventriosum*	Monterey Bay to Chile, S.A.; Gulf of California	Throughout region	Common
Dusky shark *Carcharhinus obscurus*	So. Calif. to Revillagigedo Islands, Mexico	South of Point Conception	Rare
Narrowtooth shark *Carcharhinus remotus*	So. Calif. to Peru, S.A.; Gulf of California	South of Point Conception	Rare

Source: Allan Hancock Foundation, 1975.

Table A2.1.8.1.3-2 (Continued)

COMMON NAME Genus Species	Coastal Range	Coastal Range in Region or State	Abundance
Tiger shark *Galeocerdo cuvieri*	So. Calif. to Peru, S.A.	South of Point Conception	Rare
Soupfin shark *Galeorhinus zyopterus*	North Br. Col. to Chile and Peru, S.A.	Throughout state	Common
Grey smoothhound shark *Mustelus californicus*	Cape Mendocino, California to Mazatlan, Mexico	Throughout region	Common
Brown smoothhound shark *Mustelus henlei*	Humboldt Bay to Gulf of California	Throughout region	Common
Leopard shark *Triakis semifasciata*	Oregon to Mazatlan, Mexico; Gulf of California	Throughout state	Common
Spiny dogfish *Squalus acanthias*	Alaska to Baja California	Throughout state	Common
Pacific angel shark *Squatina californica*	SE Alaska to Gulf of California; Chile, S.A.	Throughout state	Common
Thornback *Platyrhinoidis triseriata*	San Francisco to Baja California	Throughout region	Common
Shovelnose guitarfish *Rhinobatos productus*	San Francisco to Gulf of California	Throughout region	Common
Pacific electric ray *Torpedo californica*	Br. Col. to Baja California	Throughout state	Common
Big skate *Raja binoculata*	Bering Sea to San Quintin Bay, Baja California	Throughout state	Common

Table A2.1.8.1.3-2 (Continued)

COMMON NAME Genus Species	Coastal Range	Coastal Range in Region or State	Abundance
California skate Raja inornata	Strait of Juan de Fuca to Baja California	Throughout state	Common
Diamond stingray Dasyatis dipterura	Kyuquot, Br. Col. to Prita, Peru, S.A.	Throughout state	Common
California butterfly ray Gymnura marmorata	Pt. Conception, California to Peru, S.A.	Throughout region	Common
Round stingray Urolophus halleri	Humboldt Bay, California to Panama Bay, C.A.	Throughout region	Common
Bat stingray Myliobatis californica	Oregon to Gulf of California	Throughout state	Common
Ratfish Hydrolagus colliei	SE Alaska to Gulf of California	Throughout state	Common
Pacific herring Clupea harengus pallasi	Arctic Alaska to North Baja California	Throughout state	Common
Round herring Etrumeus teres	Monterey Bay, California to Chile, S.A.	Throughout region	Uncommon
Middling thread herring Opisthonema medirastre	Redondo Beach, California to Peru, S.A.; Gulf of Calif.	So. of Redondo Beach	Uncommon
Pacific sardine Sardinops sagax	Kamchatka, Alaska to Guaymas, Mexico	Throughout state	Common
Deepbody anchovy Anchoa compressa	Morro Bay to Todos Santos Bay, Baja California	Throughout region	Common

Table A2.1.8.1.3-2 (Continued)

COMMON NAME Genus Species	Coastal Range	Coastal Range in Region or State	Abundance
Anchoveta Centengraulis mysticetus	L.A. Harbor to Sechura Bay, Peru, S.A.	So. of L.A. Harbor	Rare
Northern anchovy Engraulis mordax	Queen Charlotte Is., Br. Col. to Cape San Lucas, Baja Calif.	Throughout state	Abundant in region
Slough anchovy Anchoa delicatissima	Belmont Shores to Magdalena Bay, Baja California	So. of Belmont Shores	Common
Coho (Silver) salmon Oncorhynchus kisutch	Bering Sea to Chamalu Bay, Baja California	Throughout state	Common no. of Santa Barbara
Whitebait smelt Allosmerus elongatus	Strait of Juan de Fuca, Br. Col. to San Pedro, California	No. of San Pedro	Uncommon
Surf smelt Hypomesus pretiosus	Prince William Sound, Alaska to Long Beach, California	No. of Long Beach	Common
California lizardfish Synodus lucioceps	San Francisco to Guaymas, Mex.	Throughout region	Uncommon
Longnose lancetfish Alepisaurus ferox	Unalaska Is., Alaska to Chile, S.A.	Throughout state	Uncommon
California moray Gymnothorax mordax	Pt. Conception to Baja Calif.	Throughout region	Common
Pacific worm eel[a] Myrophis vafer	San Pedro to Peru, S.A.; Gulf of California	So. of San Pedro	Rare

[a] Intertidal

Table A2.1.8.1.3-2 (Continued)

COMMON NAME Genus Species	Coastal Range	Coastal Range in Region or State	Abundance
Pacific snake eel Ophichthus triserialis	Humboldt Bay, Calif. to Peru, S.A.; Gulf of Calif.	Throughout region	Rare
Yellow snake eel[a] Ophichthus zophochir	Berkeley, Calif. to Peru, S.A.; Gulf of California	Throughout region	Rare
California needlefish Strongylura exilis	San Francisco, California to Peru, S.A.	Throughout region	Uncommon
California halfbeak Hyporhamphus rosae	Santa Ana River, California to Mazatlan, Mexico	So. of Santa Ana River	Rare
California flyingfish Cypselurus californicus	Astoria, Oregon to Cape San Lucas, Baja California	Throughout state	Common so. of Pt. Conception
California killifish Fundulus parvipinnis	Morro Bay, Calif. to Almejas Bay, Baja California	Throughout region	Common
Pacific hake Merluccius productus	Alaska to Magdalena Bay, Baja California	Throughout region	Common
Pacific tomcod Microgadus proximus	Bering Sea to Los Angeles, California	No. of L.A.	Common
Tube-snout Aulorhynchus flavidus	Sitka, Alaska to Pt. Rompiente, Baja California	Throughout state	Uncommon
Slender snipefish Macrorhamphosus gracilis	Santa Monica Bay to SE Pacific	So. of Santa Monica Bay	Common
Snubnose pipefish Syngnathus arctus	Tomales Bay to Mazatlan, Mex.	Throughout region	Uncommon

Table A2.1.8.1.3-2 (Continued)

COMMON NAME Genus Species	Coastal Range	Coastal Range in Region or State	Abundance
Barred pipefish Syngnathus auliscus	Pt. Conception to Panama, C.A.	Throughout region	Uncommon
Kelp pipefish Syngnathus californiensis	San Francisco, Calif. to Santa Maria Bay, Baja Calif.	Throughout region	Common
Bay pipefish Syngnathus griseolineatus	Sitka, Alaska to Black Warrior Lagoon, Baja California	Throughout state	Common
Spotted cabrilla Epinephelus analogus	San Pedro, California to Peru, S.A.	So. of San Pedro	Rare
Splittail bass Hemanthias peruanus	Redondo Beach, California to Chile, S.A.	So. of Redondo Beach	Rare
Broomtail grouper Mycteroperca xenarcha	San Francisco Bay to Paita, Peru, S.A.	Throughout region	Rare
Kelp bass Paralabrax clathratus	Columbia River to Magdalena Bay, Baja California	Throughout state	Common
Spotted sand bass Paralabrax maculatofasciatus	Monterey, Calif. to Mazatlan, Mexico; Gulf of California	Throughout region	Common
Barred sand bass Paralabrax nebulifer	Santa Cruz, California to Magdalena Bay, Baja Calif.	Throughout region	Common
Giant sea bass Stereolepis gigas	Humboldt Bay to Gulf of Calif.	Throughout region	Common so. of Channel Is.
Striped bass Morone saxatilis	Barkley Sound, Br. Col. to So. of Calif./Mex. border	Throughout state	Common no. of Monterey Bay

Table A2.1.8.1.3-2 (Continued)

COMMON NAME Genus Species	Coastal Range	Coastal Range in Region or State	Abundance
Pacific flagfin mojarra *Eucinostomus gracilis*	Anaheim Bay, Calif. to Callao, Perù, S.A.	So. of Anaheim Bay	Rare
Sargo *Anisotremus davidsoni*	Santa Cruz, California to Magdalena Bay, Baja Calif.	Throughout region	Common so. of Pt. Conception
Salema *Xenistius californiensis*	Monterey Bay, California to Peru, S.A.	Throughout region	Common so. of Pt. Conception
Black croaker *Cheilotrema saturnum*	Pt. Conception to Magdalena Bay, Baja California	Throughout region	Common
White seabass *Cynoscion nobilis*	Juneau, Alaska to Magdalena Bay, Baja California	Throughout state	Common
White croaker *Genyonemus lineatus*	Vancouver Is., Br. Col. to Magdalena Bay, Baja Calif.	Throughout state	Common
California corbina *Menticirrhus undulatus*	Pt. Conception to Gulf of California	Throughout region	Common
Spotfin croaker *Roncador stearnsi*	Pt. Conception to Mazatlan, Mexico	Throughout region	Common
Queenfish *Seriphus politus*	Yaquina Bay, Oregon to Uncle Sam Bank, Baja Calif.	Throughout state	Common
Yellowfin croaker *Umbrina roncador*	Pt. Conception to Gulf of California	Throughout region	Common
Pacific porgy *Calamus brachysomus*	Oceanside, Calif. to 150 miles so. of Lima, Peru, S.A.	So. of Oceanside	Rare

Table A2.1.8.1.3-2 (Continued)

COMMON NAME *Genus Species*	Coastal Range	Coastal Range in Region or State	Abundance
Opaleye[a] *Girella nigricans*	San Francisco to Cape San Lucas, Baja California	Throughout region	Common
Zebra perch[a] *Hermosilla azurea*	Monterey, Calif. to Gulf of California	Throughout region	Uncommon
Halfmoon *Medialuna californiensis*	Crescent City, Calif. to Gulf of California	Throughout region	Common
Barred surfperch *Amphistichus argenteus*	Bodega Bay, Calif. to Playa Maria Bay, Baja California	Throughout region	Common
Calico surfperch *Amphistichus koelzi*	Shi Shi Beach, Wash. Arroyo San Isidro, Baja Calif.	Throughout state	Common
Kelp perch *Brachyistius frenatus*	Vancouver Is. Br. Col. to Turtle Bay, Baja California	Throughout state	Common
Shiner perch *Cymatogaster aggregata*	Port Wrangell, Alaska to San Quintin Bay, Baja Calif.	Throughout state	Common
Black perch *Embiotoca jacksoni*	Fort Bragg, Calif. to Pt. Abreojos, Baja Calif.	Throughout region	Common
Striped seaperch *Embiotoca lateralis*	Port Wrangell, Alaska to Pt. Cabras, Baja California	Throughout state	Common
Spotfin surfperch *Hyperprosopon anale*	Seal Rock, Oregon to Blanca Bay, Baja California	Throughout state	Uncommon
Walleye surfperch *Hyperprosopon argenteum*	Vancouver Is. Br. Col. to Pt. San Rosarito, Baja Calif.	Throughout state	Common

Table A2.1.8.1.3-2 (Continued)

COMMON NAME Genus Species	Coastal Range	Coastal Range in Region or State	Abundance
Silver surfperch Hyperprosopon ellipticum	Vancouver Is. Br. Col. to Rio San Vicente, Baja Calif.	Throughout state	Common
Rainbow seaperch Hypsurus caryi	Cape Mendocino, Calif. to Rio Santo Thomas, Baja Calif.	Throughout region	Common
Reef perch[a] Micrometrus aurora	Tomales Bay, Calif. to Pt. Baja, Baja California	Throughout region	Common
Dwarf perch[a] Micrometrus minimus	Bodega Bay, Calif. to Cedros Is. Baja California	Throughout region	Common
Sharpnose seaperch Phanerodon atripes	Bodega Bay, Calif. to San Benito Is. Baja California	Throughout region	Uncommon
White seaperch Phanerodon furcatus	Vancouver Br. Col. to Pt. Cabras, Baja California	Throughout state	Common
Rubberlip seaperch Rhacochilus toxotes	Mendocino Co., Calif. to Thurloe Head, Baja California	Throughout region	Common
Pile perch Rhacochilus vacca	Port Wrangell, Alaska to Guadalupe Isle	Throughout state	Common
Pink seaperch Zalembius rosaceus	Drakes Bay, Calif. to Gulf of Calif. & San Cristobal Bay, Baja California	Throughout region	Uncommon
Blacksmith Chromis punctipinnis	Monterey Bay, Calif. to Pt. San Pablo, Baja California	Throughout region	Common so. of Pt. Conception

Table A2.1.8.1.3-2 (Continued)

COMMON NAME *Genus Species*	Coastal Range	Coastal Range in Region or State	Abundance
Garibaldi *Hypsypops rubicunda*	Monterey Bay, Calif. to Magdalena Bay, baja Calif.	Throughout region	Common so. of Pt. Conception
Rock wrasse *Halichoeres semicinctus*	Pt. Conception to Gulf of California	Throughout region	Common
Senorita *Oxyjulis californica*	Sausalito, Calif. to Cedros Is., Baja California	Throughout region	Common
California sheephead *Pimelometopon pulchrum*	Monterey Bay, Calif. to Cape San Luis, Baja California	Throughout region	Common so. of Pt. Conception
Slender tuna *Allothunnus fallai*	L.A. Harbor so. to So. Hemisphere	So. of L.A. Harbor	Rare
Kawakawa *Euthynnus affinis*	L.A. Harbor to Indo-Pacific	So. of L.A. Harbor	Rare
Pacific bonito *Sarda chiliensis*	Gulf of Alaska to Chile, S.A.	Throughout state	Common
Chub mackerel *Scomber japonicus*	Gulf of Alaska to Chile, S.A.	Throughout state	Common
Monterey spanish mackerel *Scomberomorus concolor*	Soquel, California to Gulf of California	Throughout region	Rare
Sierra *Scomberomorus sierra*	Santa Monica, California to Paita, Peru, S.A.	So. of Santa Monica	Rare
Arrow goby *Clevelandia ios*	Vancouver Is., Br. Col. to Gulf of California	Throughout state	Common

Table A2.1.8.1.3-2 (Continued)

COMMON NAME Genus Species	Coastal Range	Coastal Range in Region or State	Abundance
Blackeye goby Coryphopterus nicholsi	Queen Charlotte Is., Br. Col. to Pt. Rompiente, Baja Calif.	Throughout state	Common
Longjaw mudsucker Gillichthys mirabilis	Tomales Bay, Calif. to Gulf of California	Throughout region	Common
Bay goby Lepidogobius lepidus	Vancouver Is., Br. Col. to Cedros Is., Baja California	Throughout state	Common
California scorpionfish Scorpaena guttata	Santa Cruz, Calif. to Uncle Sam Bank, Baja California	Throughout region	Common so. of Pt. Conception
Kelp rockfish Sebastes atrovirens	Timber Cove, Sonoma Co., Calif. to Pt. San Pablo, Baja Calif.	Throughout region	Common
Brown rockfish Sebastes auriculatus	SE Alaska to Hipolito Bay, Baja California	Throughout state	Common
Gopher rockfish Sebastes carnatus	Eureka, Calif. to San Roque, Baja California	Throughout region	Common
Black and yellow rockfish[a] Sebastes chrysomelas	Eureka, Calif. to Natividad Is., Baja California	Throughout region	Common
Calico rockfish Sebastes dalli	San Francisco, Calif. to Sebastian Viscaino Bay, Baja Calif.	Throughout region	Common
Widow rockfish Sebastes entomelas	Kodiak Is. to Todos Santos Bay, Baja California	Throughout state	Common
Yellowtail rockfish Sebastes flavidus	Kodiak Is. to San Diego, Calif.	Throughout state	Common

Table A2.1.8.1.3-2 (Continued)

COMMON NAME Genus Species	Coastal Range	Coastal Range in Region or State	Abundance
Chilipepper Sebastes goodei	Vancouver Is., Br. Col. to Magdalena Bay, Baja Calif.	Throughout state	Common
Vermilion rockfish Sebastes miniatus	Vancouver Is., Br. Col. to Benito Is., Baja California	Throughout state	Common
Blue rockfish Sebastes mystinus	Bering Sea to Pt. Santo Tomas, Baja California	Throughout state	Common
China rockfish Sebastes nebulosus	SE Alaska to San Miguel Is.	Throughout state	Common
Bocaccio Sebastes paucispinis	Kodiak Is., Alaska to Pt. Blanca, Baja California	Throughout state	Common
Grass rockfish Sebastes rastrelliger	Yaquina Bay, Oregon to Playa Maria Bay, Baja California	Throughout state	Common
Flag rockfish Sebastes rubrivinctus	Aleutian Is. to Cape Colnett, Baja California	Throughout state	Common
Stripetail rockfish Sebastes saxicola	SE Alaska to Sebastian Viscaino Bay, Baja Calif.	Throughout state	Common
Olive rockfish Sebastes serranoides	Del Norte Co., Calif. to San Benito Is., Baja Calif.	Throughout region	Common
Treefish Sebastes serriceps	San Francisco, Calif. to Cedros Is., Baja Calif.	Throughout region	Common
Whitebelly rockfish Sebastes vexillaris	Crescent City, Calif. to San Benito Is., Baja Calif.	Throughout region	Common

Table A2.1.8.1.3-2 (Continued)

COMMON NAME Genus Species	Coastal Range	Coastal Range in Region or State	Abundance
Kelp greenling[a] *Hexagrammos decagrammus*	Aleutian Is., Alaska to La Jolla, Calif.	So. to La Jolla	Common
Lingcod *Ophiodon elongatus*	Kodiak Is., Alaska to Pt. San Carlos, Baja Calif.	Throughout state	Common
Longspine combfish *Zaniolepis latipinnis*	Vancouver Is., Br. Col. to San Cristobal Bay, Baja Calif.	Throughtout state	Common
Roughcheek sculpin[a] *Artedius creaseri*	Pescadero Pt., Calif. to Pt. San Pablo, Baja Calif.	Throughout region	Uncommon
Bonehead sculpin[a] *Artedius notospilotus*	Puget Sound to Pt. San Telmo, Baja Calif.	Throughout state	Uncommon
Roughback sculpin[a] *Chitonotus pugetensis*	Ucluelet, Br. Col. to Santa Maria Bay, Baja Calif.	Throughout state	Uncommon
Wooly sculpin[a] *Clinocottus analis*	Cape Mendocino, Calif. to Ascuncion Pt., Baja Calif.	Throughout region	Common
Pacific staghorn sculpin[a] *Leptocottus armatus*	Chignik, Alaska to San Quintin Bay, Baja Calif.	Throughout state	Common
Tidepool sculpin[a] *Oligocottus maculosus*	Sea of Okhotsk to Whites Pt., California	No. of Whites Pt.	Common

Table A2.1.8.1.3-2 (Continued)

COMMON NAME *Genus Species*	Coastal Range	Coastal Range in Region or State	Abundance
Saddleback sculpin[a] *Oligocottus rimensis*	Br. Col. to San Nichols Is., Baja California	Throughout state	Common
Cabezon[a] *Scorpaenichthys marmoratus*	Sitka, Alaska to Pt. Abreojos, Baja California	Throughout state	Common
Pygmy poacher *Odontopyxis trispinosa*	SE Alaska to Cedros Is., Baja California	Throughout state	Common
Spotted kelpfish *Gibbonsia elegans*	Pt. Piedras Blancas to Magdalena Bay, Baja Calif.	Throughout region	Common
Giant kelpfish *Heterostichus rostratus*	Br. Col. to Cape San Lucas, Baja California	Throughout state	Common
Sarcastic fringehead *Neoclinus blanchardi*	San Francisco, Calif. to Cedros Is., Baja Calif.	Throughout region	Uncommon
Yellowfin fringehead *Neoclinus stephensae*	Monterey, Calif. to Pt. San Hipolito	Throughout region	Uncommon
Onespot fringehead *Neoclinus uninotatus*	Bodega Bay, Calif. to San Diego Bay, Calif.	Throughout region	Uncommon
Rockpool blenny[a] *Hypsoblennius gilberti*	Monterey, Calif. to Magdalena Bay, Baja Calif.	Throughout region	Common
Mussel blenny[a] *Hypsoblennius jenkinsi*	Coal Oil Pt., Calif. to Puerta Marquis, Mexico	Throughout region	Common

Table A2.1.8.1.3-2 (Continued)

COMMON NAME Genus Species	Coastal Range	Coastal Range in Region or State	Abundance
Spotted cusk-eel Otophidium taylori	No. Oregon to San Cristobal Bay, Baja California	Throughout state	Common
Basketweave cusk-eel Otophidium scrippsae	Pt. Arguello to Guaymas, Mexico	Throughout region	Uncommon
Pacific pompano Peprilus simillimus	Fraser River Br. Col. to Magdalena Bay, Baja Calif.	Throughout state	Common
Pacific barracuda Sphyraena argentea	Kodiak Is., Alaska to Cape San Luis, Baja California	Throughout state	Common so. of Morro Bay
Striped mullet Mugil cephalus	Monterey Bay, Calif. to Galapagos Island	Throughout region	Common
Topsmelt Atherinops affinis	Vancouver Is., Br. Col. to Gulf of California	Throughout state	Common
Jacksmelt Atherinopsis californiensis	Yaquina Bay, Oregon to Santa Maria Bay, Baja Calif.	Throughout state	Common
California grunion Leuresthes tenuis	San Francisco, Calif. to Magdalena Bay, Baja Calif.	Throughout region	Common so. of Pt. Conception
Yellow bobo Polydactylus opercularis	Monterey, Calif. to Callao, Peru, S.A.	Throughout region	Rare

Table A2.1.8.1.3-2 (Continued)

COMMON NAME Genus Species	Coastal Range	Coastal Range in Region or State	Abundance
Pacific sanddab Citharichthys sordidus	Bering Sea to Cape San Lucas, Baja California	Throughout state	Common
Speckled sanddab Citharichthys stigmaeus	Montague Is., Alaska to Magdalena Bay, Baja Calif.	Throughout state	Common
Longfin sanddab Citharichthys xanthostigma	Monterey Bay, Calif. Costa Rica	Throughout region	Common
Bigmouth sole Hippoglossina stomata	Monterey Bay, Calif. to Gulf of California	Throughout region	Uncommon
California halibut Paralichthys californicus	Quillayute River, Br. Col. to Magdalena Bay, Baja Calif.	Throughout state	Common
Fantail sole Xystreurys liolepis	Monterey Bay, Calif. to Gulf of California	Throughout region	Uncommon
Petrale sole Eopsetta jordani	Gulf of Alaska to Los Coronados Is., Baja Calif.	Throughout state	Common
Rex sole Glyptocephalus zachirus	Bering Sea to San Diego Trough	Throughout state	Common
Pacific halibut Hippoglossus stenolepis	Bering Sea to Santa Rosa Is.	Throughout region	Uncommon
Diamond turbot Hypsopsetta guttulata	Cape Mendocino, Calif. to Magdalena Bay, Baja Calif.	Throughout region	Common
Butter sole Isopsetta isolepis	Bering Sea to Ventura, Calif.	Throughout state	Common

Table A2.1.8.1.3-2 (Continued)

COMMON NAME Genus Species	Coastal Range	Coastal Range in Region or State	Abundance
English sole *Parophrys vetulus*	NW Alaska to San Cristobal Bay, Baja California	Throughout state	Common
C-O sole *Pleuronichthys coenosus*	SE Alaska to Cape Colnett, Baja California	Throughout state	Common
Curlfin sole *Pleuronichthys decurrens*	NW Alaska to San Quintin Bay, Baja California	Throughout state	Common
Spotted turbot *Pleuronichthys ritteri*	Pt. Conception to Magdalena Bay, Baja California	So. of Pt. Conception	Common
Hornyhead turbot *Pleuronichthys verticalis*	Pt. Reyes, Calif. to Magdalena Bay, Baja Calif.	Throughout region	Common
California tonguefish *Symphurus atricauda*	Big Lagoon, Humboldt Co., Calif. to Cape San Lucas, Baja Calif.	Throughout region	Common
Bearded clingfish[a] *Gobiesox papillifer*	San Pedro, Calif. to Panama Bay	So. of San Pedro	Uncommon
California clingfish *Gobiesox rhessodon*	Gaviota, Calif. to San Bartolome Bay, Baja Calif.	So. of Gabiota	Uncommon
Slender clingfish[a] *Rimicola eigenmanni*	Palos Verdes Pen., Calif. to San Juanico Bay, Baja Calif.	So. of Palos Verdes Pen.	Uncommon
Specklefin midshipman *Porichthys myriaster*	Pt. Conception to Magdalena Bay, Baja California	Throughout region	Common
Plainfin midshipman *Porichthys notatus*	Sitka, Alaska to Gorda Bank, Baja California, Gulf of Calif.	Throughout state	Common

<u>Appendix 2.1.8.1.3</u>

1. Allan Hancock Foundation. 1975. Report to the U.S. Army Corps of Engineers on Environmental Investigation and Analysis. Los Angeles Harbor 1973-1975. Allan Hancock Foundation, University of Southern California, Los Angeles, CA.

2. Environmental Quality Analysts, Inc. and Marine Biological Consultants, Inc. 1975. Marine Monitoring Studies; 1974 Annual Report. Southern California Edison Co., Long Beach Generating Station. Vol. 2, June 1975.

APPENDIX A2.1.8.1.3-A

Fishery Production Summary

Appendix A2.1.8.1.3-A

Fishery Production Summary

1957 to 1958

During these years, abnormally high water temperatures brought in large numbers of bonito, yellowtail, and barracuda, which greatly increased the demand for anchovy. The Los Angeles-Long Beach Harbor had the heaviest fishing effort and largest bait production. Through August, 1957, boats from Santa Monica, Newport, San Clemente, and Oceanside also fished the harbor to collect their quotas. "Pinheads" (immature anchovy) were abundant from June 1957 through 1958. Fishermen from the harbor traveled to Newport Beach for their bait during May, June, and September, 1958.

1959 to 1960

"Pinheads" were still abundant through 1959 and several months of 1960. Los Angeles-Long Beach Harbor bait fish averaged 3.6 to 4.6 inches in length. Stomach analysis of offshore predator fish indicated larger anchovy were utilizing colder waters. In April, 1960, larger fish appeared in the harbor; the fishing improved but the fish were still fairly small. Bait fishing remained good throughout the season.

1961 to 1962

During the summer of 1961, more problems with pinheads occurred in the harbor. The fishermen were forced outside the breakwaters for short periods in September. In April, 1962, fishermen were again forced 6 to 8 miles outside the breakwater to locate fish. In May fishing returned to the harbor. Pinheads continued to plague the fishermen from July to September.

1963

In March the anchovy were difficult to find. From April to November, however, the Los Angeles-Long Beach Harbor had abundant anchovy and provided the largest portion of the catch. Boats from Newport, San Diego, and Oceanside fished the harbor, accounting for 80 percent of all live bait taken in July from southern California. Pinheads appeared from October to December, but low demand created few problems.

1964

Anchovies 6 inches long were reported off Newport Beach and Los Angeles through February. During July and August, bait haulers from Newport traveled to the Los Angeles-Long Beach Harbor to fill their baitfish needs. Sport-fishing activity and demand dropped off after Labor Day. San Diego fishermen purchased bait from Los Angeles bait haulers in September.

1965

No major problems were encountered early in the year. Red-tide conditions in July in the Santa Monica Bay created problems. In August, bait haulers from Newport, Oceanside, and San Diego spent many days in Los Angeles-Long Beach Harbor to meet commitments. During November, the California Fish and Game Commission adopted regulations for an anchovy reduction fishery. This affected live-bait fishermen.

1966

Over 95 percent of the live bait catch (6,740 tons) was captured in southern California. This was an increase of 600 tons from 1965, which reflected increased demand for bait fish, not changes resulting from the reduction fishery. During the summer, San Diego fishermen traveled to Los Angeles once or twice a week to meet their fish-bait demands, as they had on

numerous occasions during at least 5 of the past 10 years. Oceanside and Santa Monica bait haulers fished in the Los Angeles-Long Beach Harbor during June and July. During the fall and winter months, fish were abundant throughout southern California.

1967

This was a very good year for live-bait fishermen. Fish (6-8 inches) were abundant from March to May from San Diego to Los Angeles. San Pedro Bay was the major fishing ground in mid-July. The bait remained abundant through the year.

1968 to 1969

The 1968 season was a poor one. Until March, anchovy were unavailable south of Los Angeles. The live bait fishery centered in the harbor until late July. A large pinhead influx occurred in the harbor during August and September. Fishing moved outside the breakwaters. The same general pattern existed until February, 1969. The fish were unavailable in the harbor, and Los Angeles haulers fished off Newport. Fishing improved in March; and in April, large anchovy schools moved inshore off Newport Beach and inside Los Angeles-Long Beach Harbor. The schools were so large, however, that the fishermen had difficulty capturing the fish. The harbor was the peak activity area through August. By the end of the month, fishing was good along the coast. Pinheads appeared in the harbor, and fishing was forced outside the breakwater for the remainder of the season.

1970 to 1972

These seasons were the most successful of the past 15 years. Generally, all along the coast, the fish were abundant until March, decreased until May, and increased through early fall.

1973

This year was similar to the poor seasons of 1958 and 1959. There was a large influx of warm water and of yellowtail through September. In early spring, the anchovy did not school consistently in Los Angeles Harbor. Fishing was forced outside the breakwaters and off Newport Beach. From June to September there was a large pinhead influx. Some boats from Newport Beach fished in the harbor. Late in September, large schools of fish moved inshore, generally removing the pressure on the bait-fish industry. Los Angeles-Long Beach Harbor was an exception, however, and fishing was done outside the breakwater.

The growing party-boat industry and other sport-fishing activities have exerted great pressure on live-bait fishermen to meet the demands. These brief summaries, excerpted from a manuscript by Maxwell (1974), illustrate some of the fluctuations and problems of the fishery, particularly in the Los Angeles-Long Beach Harbor.

REFERENCES

Appendix 2.1.8.1.3-A

1. Maxwell, W.D. 1974. A History of the California Live-Bait Fishing Industry. Marine Res. Rech. Rept. 27, Calif. Dept. of Fish and Game, Sacramento, CA.

APPENDIX A2.1.8.2

Species Occurring Within Major Biomes or Aquatic Areas

Along the Pipeline Route

Table A2.1.8.2-1

Reptiles Existing or Potentially Occurring within Major Biomes in the Vicinity of the Proposed Pipeline Route

COMMON NAME Scientific Name	Major Biomes[a]							
		Sonoran Desert						
	CC	CD(C)	YD	AUD	DG	CD	TPDS	SGP
Desert tortoise *Gopherus agassizi*		X	X					
Snapping turtle *Chelydra serpentina*								X
Yellow mud turtle *Kinosternon flavescens*				X	X			
Sonora mud turtle *K. sonoriense*			X	X	X			
Western box turtle *Terrapene ornata*				X		X		X
Southwestern pond turtle *Clemmys marmorata pallida*	X	X						
Pond slider *Pseudemys scripta*								X
Texas slider *P. concinna texana*								X
Spiny softshell turtle *Trionyx spiniferus*						X	X	X
Desert night lizard *Xantusia vigilis*		X						
Granite night lizard *X. henshawi*		X						
Lesser earless lizard *Holbrookia maculata*				X		X		X
Greater earless lizard *H. texana*				X	X	X	X	X

Source: Data modified from Stebbins, 1954, 1966; Sargeant, 1966 Cagle, 1968; Head, 1972; U.S. Bureau of Sport Fisheries and Wildlife, 1973; Brode, 1974; pamphlet from Tucker Wildlife Sanctuary, Irvine, CA.

[a] Column abbreviations: CC, California Coastal; CD(C), Colorado Desert (California); YD, Yuman Desert; AUD, Arizona Upland Desert; DG, Desert Grassland; CD, Chihuahuan Desert; TPDS, Trans-Pecos Desert Scrub; SGP, Short-Grass Prairie.

Table A2.1.8.2-1 (Continued)

COMMON NAME Scientific Name	Major Biomes[a]							
		Sonoran Desert						
	CC	CD(C)	YD	AUD	DG	CD	TPDS	SGP
Leaf-toed gecko *Phyllodactylus nocticolus*		X						
Banded gecko *Coleonyx variegatus*		X	X	X				
San Diego banded gecko *C. v. abbotti*		X						
Desert iguana *Dipsosaurus dorsalis*		X	X					
Chuckwalla *Sauromalus obesus*		X	X					
Zebra-tailed lizard *Callisaurus draconoides*		X	X	X				
Mojave fringe-toed lizard *Uma scoparia*		X						
Colorado desert fringe-toed lizard *U. notata*		X						
Coachella Valley fringe-toed lizard *U. inornata*		X						
Crevice spiny lizard *Sceloporus poinsetti*						X	X	
Clark's spiny lizard *S. clarki*					X			
Collard lizard *Crotaphytus collaris*		X	X	X	X	X	X	X
Leopard lizard *C. wislizeni*		X	X	X	X	X	X	
Yellow-backed spiny lizard *Sceloporus magister uniformis*		X						
Great Basin fence lizard *S. occidentalis biseriatus*		X						
Desert spiny lizard *S. magister*			X	X	X	X	X	
Sagebrush lizard *S. graciosus*		X	X					
Granite spiny lizard *S. orcutti*		X						

Table A2.1.8.2-1 (Continued)

COMMON NAME Scientific Name	Major Biomes[a]							
		Sonoran Desert						
	CC	CD(C)	YD	AUD	DG	CD	TPDS	SGP
Eastern fence lizard S. undulatus						X	X	X
Tree lizard Urosaurus ornatus		X	X	X	X	X	X	X
Western brush lizard U. graciosus		X						
Side-blotched lizard Uta stansburiana	X	X	X	X	X	X	X	X
Desert side-blotched lizard U. s. stejnegeri		X						
Texas horned lizard Phrynosoma cornutum						X	X	X
Short-horned lizard P. douglassi					X			
Round-tailed horned lizard P. modestum						X		
Desert horned lizard P. platyrhinos		X	X					
Regal horned lizard P. solare			X	X				
San Diego horned lizard P. coronatum blainvillei	X							
Flat-tailed horned lizard P. m'calli		X						
Arizona alligator lizard Gerrhonotus kingi					X			
San Diego alligator lizard G. multicarinatus scincicauda	X	X						
Western red-tailed skink Eumeces gilberti rubricaudatus	X	X						
Coronado Island skink E. skiltonianus interparietalis	X							
Western skink E. s. skiltonianus	X	X						
Checkered whiptail Cnemidophorus tessellatus						X	X	

Table A2.1.8.2-1 (Continued)

COMMON NAME Scientific Name	CC	Major Biomes[a] Sonoran Desert CD(C)	YD	AUD	DG	CD	TPDS	SGP
Western whiptail C. tigris		X	X		X	X	X	X
Coastal whiptail C. t. multiscutatus		X						
Whiptail C. exsanguis					X			
Texas spotted whiptail C. gularis								X
Little striped whiptail C. inornatus						X		
Six-lined racerunner C. sexlineatus								X
Desert grassland whiptail C. uniparens						X		
Giant spotted whiptail C. burti stictogrammus					X			
New Mexican whiptail C. neomexicanus						X		
Great Plains skink Eumeces obsoletus						X	X	X
Many-lined skink E. multivirgatus							X	
Gila monster Heloderma suspectum			X	X	X			
Silvery legless lizard Anniella pulchra pulchra		X						
Texas blind snake Leptotyphlops dulcis						X		X
Western blind snake L. humilis	X	X	X			X		
Southwestern blind snake L. h. humilis	X	X						
Coastal rosy boa Lichanura trivirgata roseofusca	X	X						
Desert rosy boa L. t. gracia			X					
Southern rubber boa Charina bottae	X							

Table A2.1.8.2-1 (Continued)

COMMON NAME Scientific Name	Major Biomes[a]							
		Sonoran Desert						
	CC	CD(C)	YD	AUD	DG	CD	TPDS	SGP
Blotched water snake *Natrix erythrogaster transversa*								X
Regal ringneck snake *Diadophis punctatus regalis*					X		X	
San Diego ringneck snake *D. p. similis*	X	X						
Corn snake *Elaphe guttata*								X
Trans-Pecos rat snake *E. subocularis*						X	X	
California striped racer *Masticophis lateralis*		X						
Coachwhip *M. flagellum*		X	X	X	X	X	X	X
Sonora coachwhip *M. f. cingulum*					X			
Sonora whipsnake *M. bilineatus*				X	X			
Striped whipsnake *M. taeniatus*						X	X	
Western yellow-bellied racer *Coluber constrictor mormon*	X	X						
Mountain patch-nosed snake *Salvadora grahamiae*							X	
Western patch-nosed snake *S. hexalepis*		X	X	X	X	X		
Coast patch-nosed snake *S. h. virgultea*	X	X						
Mojave patch-nosed snake *S. h. mojavensis*		X						
Saddled leaf-nosed snake *Phyllorhynchus browni*				X				
Western leaf-nosed snake *P. decurtatus*		X						
Spotted leaf-nosed snake *P. decurtatus*			X					
Sonora gopher snake *Pituophis melanoleucus*		X	X	X	X	X	X	X

Table A2.1.8.2-1 (Continued)

COMMON NAME Scientific Name	Major Biomes[a] CC	Sonoran Desert CD(C)	Sonoran Desert YD	Sonoran Desert AUD	DG	CD	TPDS	SGP
San Diego gopher snake *P. m. annectens*	X	X						
Glossy snake *Arizona elegans*	X	X	X	X	X	X	X	X
Common kingsnake *Lampropeltis getulus*	X	X	X	X	X	X	X	X
Yuma kingsnake *L. g. yumensis*		X						
Milk snake *L. doliata*								X
Sonora mountain kingsnake *L. pryomelana*			X	X				
San Diego mountain kingsnake *L. zonata pulchra*		X						
Long-nosed snake *Rhinocheilus lecontei*	X	X	X	X		X		X
Ground snake *Sonora episcopa*							X	X
Western ground snake *S. semiannulata*		X	X	X		X		
Checkered garter snake *Thamnophis marcianus*		X	X	X		X		X
Pecos ribbon snake *T. proximus diabolicus*						X		
Common garter snake *T. sirtalis*							X	
Mexican garter snake *T. eques*				X	X			
Black-necked garter snake *T. cyrtopsis*				X	X	X	X	
California red-sided garter snake *T. s. paristalis*	X	X						
Mountain garter snake *T. elegans elegans*	X	X						
Two-striped garter snake *T. couchi hammondi*	X	X						
Western hognose snake *Heterodon nasicus*					X	X	X	X

Table A2.1.8.2-1 (Continued)

COMMON NAME Scientific Name	Major Biomes[a]							
		Sonoran Desert						
	CC	CD(C)	YD	AUD	DG	CD	TPDS	SGP
Western shovel-nosed snake *Chionactis occipitalis*		X	X					
Sonora shovel-nosed snake *C. palarostris*				X				
Western hook-nosed snake *Ficimia cana*					X	X	X	X
Banded sand snake *Chilomeniscus cinctus*			X					
Western black-headed snake *Tantilla planiceps*		X		X	X	X		
California black-headed snake *T. p. eiseni*	X	X						
Great Plains black-headed snake *T. nigriceps*						X	X	X
Arizona coral snake *Micruroides euryxanthus*			X	X	X			
Massassauga *Sistrurus catenatus*					X	X	X	X
Night snake *Hypsiglena torquata*		X	X	X	X	X	X	X
San Diego night snake *H. t. klauberi*		X						
Sonora lyre snake *Trimorphodon lambda*		X	X	X	X			
California lyre snake *T. vandenburghi*	X	X						
Texas lyre snake *T. vilkinsoni*						X		
Black-tailed rattlesnake *Crotalus molossus*				X	X	X	X	
Banded rock rattlesnake *C. lepidus klauberi*					X	X	X	
Mottled rock rattlesnake *C. L. lepidus*							X	
Western rattlesnake *C. viridis*	X	X			X	X	X	X
Western diamondback rattlesnake *C. atrox*		X	X	X	X	X	X	X

Table A2.1.8.2-1 (Continued)

COMMON NAME Scientific Name	Major Biomes[a]							
		Sonoran Desert						
	CC	CD(C)	YD	AUD	DG	CD	TPDS	SGP
Red diamond rattlesnake *C. ruber*	X	X						
Tiger rattlesnake *C. tigris*				X	X			
Speckled rattlesnake *C. mitchelli*		X	X					
Mojave rattlesnake *C. scutulatus*		X	X	X		X		
Sidewinder *C. cerastes*		X	X					
Colorado desert sidewinder *C. c. Laterorepens*		X						

Table A2.1.8.2-2

Amphibians Existing or Potentially Occurring in the Vicinity of the Proposed Pipeline Route

COMMON NAME Scientific Name	Major Biomes[a] Sonoran Desert CC	 CD(C)	 YD	 AUD	 DG	 C	 TPDS	 SGP
Tiger salamander *Ambystoma tigrinum*						X	X	X
Monterey salamander *Ensatina eschscholtzi*		X						
California slender salamander *Batrachoseps attenuatus*	X	X						
Garden slender salamander *B. pacificus mator*	X	X						
Arboreal salamander *Aneides lugubris*		X						
Great Plains narrow-mouthed toad *Gastrophryne olivacea*						X		
Western spadefoot toad *Scaphiopus hammondi*	X	X		X	X	X	X	X
Plains spadefoot toad *S. bombifrons*						X		X
Couch's spadefoot toad *S. couchi*		X	X	X		X		X
California toad *Bufo boreas halophilus*	X	X						
Arroyo toad *B. microscaphus californicus*	X	X						
Great Plains toad *B. cognatus*		X	X	X		X		X

Source: Data modified from Stebbins, 1966; Sargeant, 1966; Blair, 1968; Pamphlet from Tucker Wildlife Sanctuary, Irvine, California.

[a] Column abbreviations: CC, California Coastal; CD(C), Colorado Desert (California); YD, Yuman Desert; AUD, Arizona Upland Desert; DG, Desert Grassland; CD, Chihuahuan Desert; TPDS, Trans-Pecos Desert Scrub; SGP, Short-Grass Prairie.

Table A2.1.8.2-2 (Continued)

COMMON NAME	Major Biomes							
		Sonoran Desert						
Scientific Name	CC	CD(C)	YD	AUD	DG	CD	TPDS	SGG
Green Toad B. debilis					X	X	X	X
Red-spotted toad B. punctatus	X	X	X	X	X	X	X	X
Rocky Mountain toad B. woodhousei		X		X		X		
Colorado River toad B. alvarius			X	X	X			
Texas toad B. speciosus						X	X	X
Pacific treefrog Hyla Regilla	X	X						
California treefrog H. californiae	X	X						
Canyon treefrog H. arenicolor				X	X			
Blanchard's cricket frog Acris crepitans blanchardi							X	X
Leopard frog Rana pipiens		X	X	X	X	X	X	X
Bullfrog R. catesbeiana	X	X	X	X	X	X	X	X
Mountain yellow-legged frog R. muscosa	X	X						
California red-legged frog R. aurora draytoni	X	X						
Eastern barking frog Eleutherodactylus augusti latrans								X
Burrowing tree frog Pternolyla fodiens				X	X			

Table A2.1.8.2-3

Birds Existing or Potentially Occurring Within Major Biomes

in the Vicinity of the Proposed Pipeline Route

COMMON NAME Scientific Name	Major Biomes[a]							
		Sonoran Desert						
	CC	CD(C)	YD	AUD	DG	CD	TPDS	SGP
Common loon *Gavia immer*			X	X		X		X
Eared grebe *Podiceps nigricollis*		X	X	X		X		X
Western grebe *Aechmophorus occidentalis*	X							
Pied-billed grebe *Podilymbus podiceps*	X		X	X		X		X
White pelican *Pelecanus erythrorhynchos*	X		X	X		X		X
Brown pelican *P. occidentalis*	X		X	X				
Double-crested cormorant *Phalacrocorax auritus*	X		X	X		X		X
Olivaceous cormorant *P. olivaceus*						X		
Great blue heron *Ardea herodias*	X		X	X		X		X
Green heron *Butorides virescens*	X		X	X		X		X
Cattle egret *Bubulcus ibis*	X							
Reddish egret *Dichromanassa rufescens*	X							
Great egret *Casmerodius albus*	X		X	X		X		X
Snowy egret *Egretta thula*	X		X	X		X		X

Source: Data modified from Pyle, 1961; Robbins, Bruun, and Zim, 1966; Peterson, 1969; Lane, 1971; Zabriskie, Wainwright, and Writz, 1974.

[a] Column abbreviations: CC, California Coastal; CD(C) Colorado Desert (California); YD, Yuman Desert; AUD, Arizona Upland Desert; DG, Desert Grassland; CD, Chihuahuan Desert; TPDS, Trans-Pecos Desert Scrub; SGP, Short-Grass Prairie.

COMMON NAME	Major Biomes[a]							
		Sonoran Desert						
Scientific Name	CC	CD(C)	YD	AUD	DG	CD	TPDS	SGP
Black-crowned night heron *Nycticorax nycticorax*	X		X	X		X		X
Least bittern *Ixobrychus exilis*	X							
American bittern *Botarus lentiginosus*	X		X	X		X		X
White-faced ibis *Pelgadis chihi*	X		X	X		X		X
Canada goose *Branta canadensis*	X		X	X		X		X
White-fronted goose *Anser albifrons*	X							
Snow goose *Chen caerulescens*			X	X		X		X
Black-bellied tree duck *Dendrocygna autumnalis*			X	X	X			
Mallard *Anas platyrhyncos*	X		X	X	X	X	X	X
Mexican duck *A. diazi*				X	X	X		
Gadwall *A. strepera*	X		X	X		X		X
Pintail *A. acuta*	X		X	X		X		X
Green-winged teal *A. crecca*	X		X	X		X		X
Blue-winged teal *A. discors*		X	X	X		X		X
Cinamon teal *A. cyanoptera*	X		X	X		X		X
European wigeon *A. penelope*	X							
American widgeon *A. americana*	X		X	X		X		X
Northern shoveler *A. clypeata*	X		X	X		X		X
Redhead *Aythya americana*	X		X			X		X

Table A2.1.8.2-3 (Continued)

COMMON NAME Scientific Name	Major Biomes[a]							
		Sonoran Desert						
	CC	CD(C)	YD	AUD	DG	CD	TPDS	SGP
Ring-necked duck *A. collaris*	X		X	X				X
Canvasback *A. valisineria*	X		X			X		X
Greater scaup *A. marila*			X	X		X		X
Lesser scaup *A. affinis*	X		X	X	X	X		X
Common goldeneye *Bucephala clangula*			X			X		X
Bufflehead *B. albeola*	X		X	X		X		X
Ruddy duck *Oxyura jamaicensis*	X		X	X		X		X
Hooded merganser *Lophodytes cucullatus*	X							
Common merganser *Mergus merganser*	X		X			X		X
Red-breasted merganser *M. serrator*	X							
Turkey vulture *Cathartes aura*	X	X	X	X	X	X	X	X
Black vulture *Coragyps atratus*				X		X		
California condor *Gymnogyps californianus*	X							
White-tailed kite *Elanus leucurus*	X							
Mississippi kite *Ictinia misisippiensis*				X		X		X
Goshawk *Accipiter gentilis*					X			
Sharp-shinned hawk *A. striatus*	X			X	X	X	X	X
Cooper's hawk *A. cooperii*	X			X	X	X	X	
Red-tailed hawk *Buteo jamaicensis*	X	X	X	X	X	X	X	X

Table A2.1.8.2-3 (Continued)

COMMON NAME	Major Biomes[a]							
		Sonoran Desert						
Scientific Name	CC	CD(C)	YD	AUD	DG	CD	TPDS	SGP
Red-shouldered hawk *B. lineatus*	X							
Swainson's hawk *B. swainsoni*	X	X				X		X
Zone-tailed hawk *B. albonotatus*			X	X	X			
White-tailed hawk *B. albicaudatus*				X	X			
Rough-legged hawk *B. lagopus*	X			X		X		X
Ferruginous hawk *B. regalis*	X					X		
Gray hawk *B. nitidus*				X	X			
Harris' hawk *Parabuteo unicinctus*			X	X				
Black hawk *Buteogallus anthracinus*				X	X			
Golden eagle *Aquila chrysaetos*	X	X	X	X	X	X	X	X
Bald eagle *Haliaeetus leucocephalus*	X	X	X	X	X	X	X	X
Marsh hawk *Circus cyaneus*	X	X	X	X		X		X
Osprey *Pandion haliaetus*	X		X	X	X	X	X	X
Audubon's caracara *Caracara cheriway*			X	X				
Prairie falcon *Falco mexicanus*	X	X	X	X		X		X
Peregrine falcon *F. peregrinus*	X		X	X	X	X	X	X
Aplomado falcon *F. femoralis*				X		X		
Merlin *F. columbarius*	X		X	X	X	X	X	X
American kestrel *F. sparverius*	X	X	X	X	X	X	X	X

COMMON NAME Scientific Name	Major Biomes[a]							
		Sonoran Desert						
	CC	CD(C)	YD	AUD	DG	CD	TPDS	SGP
Scaled quail *Callipepla squamata*				X		X		X
California quail *Lophortyx californicus*	X							
Gambel's quail *L. gambelii*		X	X	X		X		
Mountain quail *Oreortyx pictus*	X							
Montezuma quail *Cyrtonyx montezumae*					X			
Ring-necked pheasant *Phasianus colchicus*	X							
Chukar *Alectoris chukar*		X						
Sandhill crane *Grus canadensis*								X
Yuma clapper rail *Rallus longirostris yumanensis*	X	X	X					
Virginia rail *R. limicola*	X		X	X		X		X
Sora *Porzana carolina*	X		X			X		X
Black rail *Laterallus jamaicensis*	X	X						
Common gallinule *Gallinula chloropus*	X		X			X		X
American coot *Fulica americana*	X		X	X		X		X
Semipalmated plover *Charadrius semipalmatus*			X			X		
Snowy plover *C. alexandrinus*			X			X		X
Killdeer *C. vociferus*	X	X	X	X	X	X	X	X
Mountain plover *C. montanus*	X		X	X				
Black-bellied plover *Pluvialis squatarola*			X					

Table A2.1.8.2-3 (Continued)

COMMON NAME Scientific Name	Major Biomes[a]							
		Sonoran Desert						
	CC	CD(C)	YD	AUD	DG	CD	TPDS	SGP
Common snipe *Capella gallinago*	X		X	X		X		X
Long-billed curlew *Numenius americanus*	X		X	X		X		X
Sanderling *Calidris alba*			X			X		
Pectoral sandpiper *C. melanotos*			X			X		X
Least sandpiper *C. minutilla*	X		X	X		X		X
Semipalmated sandpiper *C. pusillus*						X		X
Western sandpiper *C. mauri*	X					X		X
Long-billed dowitcher *Limnodromus scolopaceus*			X	X		X		X
Spotted sandpiper *Actitis macularia*	X		X	X		X		X
Solitary sandpiper *Tringa solitaria*				X		X		X
Greater yellowlegs *T. melanoleuca*	X		X			X		X
Lesser yellowlegs *T. flavipes*				X		X		X
Willet *Catoptrophorus semipalmatus*			X	X		X		
Marbled godwit *Limosa fedoa*			X	X		X		
American avocet *Recurvirostra americana*			X			X		X
Black-necked stilt *Himantopus mexicanus*	X		X			X		X
Wilson's phalarope *Steganopus tricolor*	X		X	X		X		X
Northern phalarope *Lobipes lobatus*	X							
Herring gull *Larus argentatus*	X		X					X

Table A2.1.8.2-3 (Continued)

COMMON NAME	Major Biomes[a]							
		Sonoran Desert						
Scientific Name	CC	CD (C)	YD	AUD	DG	CD	TPDS	SGP
Ring-billed gull L. delawarensis	X		X			X		X
Bonaparte's gull L. philadelphia	X							
Forster's tern Sterna forsteri	X		X			X		X
California least tern S. Albifrons browni	X							
Caspian tern Hydroprogne caspia	X							
Black tern Chlidonias niger	X		X	X		X		X
Band-tailed pigeon Columba fasciata	X							
Rock dove Columba livia	X	X	X	X		X		X
Mourning dove Zenaida macroura	X	X	X	X	X	X	X	X
White-winged dove Z. asiatica	X	X	X	X		X		
Spotted dove Streptopelia chinensis	X							
Ringed turtle dove S. risoria	X							
Ground dove Columbina passerina			X	X		X		
Inca dove Scardafella inca			X	X		X		
Yellow-billed cuckoo Coccyzus americanus			X	X		X		X
Roadrunner Geococcyx californianus	X	X	X	X		X		X
Barn owl Tyto alba	X				X	X	X	X
Screech owl Otus asio	X	X	X	X	X	X	X	X
Whiskered owl O. trichopsis					X			

COMMON NAME Scientific Name	Major Biomes[a] CC	Sonoran Desert CD(C)	 YD	 AUD	 DG	 CD	 TPDS	 SGP
Flammulated owl *O. flammeolus*					X			
Great horned owl *Bubo virginianus*	X	X	X	X	X	X	X	X
Pygmy owl *Glaucidium gnoma*					X			
Ferruginous owl *G. brasilianum*			X	X				
Elf owl *Micrathene whitneyi*			X	X	X			
Western burrowing owl *Speotyto cunicularia hypugaea*	X	X	X	X	X	X	X	X
Spotted owl *Strix occidentalis*	X							
Long-eared owl *Asio otus*	X		X	X		X		
Short-eared owl *A. flammeus*	X		X	X		X		X
Saw-whet owl *Aegolius acadicus*					X			
Whip-poor-will *Caprimulgus vociferus*					X	X	X	
Poor-will *Phalaenoptilus nuttalli*	X	X	X	X	X	X	X	
Common nighthawk *Chordeiles minor*					X	X	X	X
Lesser nighthawk *C. acutipennis*	X	X	X	X		X		
Chimney swift *Chaetura pelagica*								X
Vaux's swift *C. vauxi*	X	X	X	X	X			X
White-throated swift *Aeronautes saxatalis*	X	X		X	X	X	X	X
Black-chinned hummingbird *Archilochus alexandri*	X				X	X		X
Costa's hummingbird *Calypte costae*	X	X	X	X				

Table A2.1.8.2-3 (Continued)

COMMON NAME Scientific Name	Major Biomes[a]							
		Sonoran Desert						
	CC	CD(C)	YD	AUD	DG	CD	TPDS	SGP
Anna's hummingbird C. anna	X		X	X	X	X	X	X
Broad-tailed hummingbird Selasphorus platycercus					X	X	X	X
Rufous hummingbird S. rufus	X		X	X	X	X	X	X
Allen's hummingbird S. sasin					X	X		
Calliope hummingbird Stellula calliope	X		X			X		
Rivoli's hummingbird Eugenes fulgens					X			
Broad-billed hummingbird Cynanthus latirostris				X	X			
Belted kingfisher Megaceryle alcyon	X		X	X	X	X	X	X
Common flicker Colaptes auratus	X		X	X	X	X	X	X
Gila woodpecker Centurus uropygialis			X	X	X			
Acorn woodpecker Melanerpes formicivorus	X				X	X		
Lewis' woodpecker Asyndesmus lewis	X				X	X		
Yellow-bellied sapsucker Sphyrapicus varius	X					X	X	X
Williamson's sapsucker S. thryoideus					X	X		
Hairy woodpecker Dendrocopos villosus					X	X	X	
Downy woodpecker D. pubescens	X				X	X	X	X
Ladder-backed woodpecker D. scalaris		X	X	X		X		X
Nuttall's woodpecker D. nuttallii	X							
Arizona woodpecker D. arizonae					X			

Table A2.1.8.2-3 (Continued)

COMMON NAME Scientific Name	Major Biomes[a]							
		Sonoran Desert						
	CC	CD(C)	YD	AUD	DG	CD	TPDS	SGP
Rose-throated becard *Platypsaris aglaiae*				X	X	X	X	X
Western kingbird *Tyrannus verticalis*	X		X	X	X	X	X	X
Cassin's kingbird *T. vociferans*	X			X	X	X	X	
Scissor-tailed flycatcher *Muscivora forficata*								X
Sulphur-bellied flycatcher *Myiodynastes luteiventris*					X			
Wied's crested flycatcher *Myiarchus tyrannulus*				X	X			
Ash-throated flycatcher *M. cinerascens*	X	X	X	X	X	X	X	X
Olivaceous flycatcher *M. tuberculifer*					X			
Black phoebe *Sayornis nigricans*	X		X	X	X	X	X	X
Say's phoebe *S. saya*	X	X	X	X	X	X	X	X
Traill's flycatcher *Empidonax traillii*	X				X	X	X	X
Dusky flycatcher *E. oberholseri*			X	X		X		
Gray flycatcher *E. wrightii*	X	X	X	X		X		X
Western flycatcher *E. difficilis*	X				X	X		
Buff-breasted flycatcher *E. fulvifrons*					X			
Coues' flycatcher *Contopus pertinax*					X	X		
Western wood pewee *C. sordidulus*				X	X	X	X	X
Olive-sided flycatcher *Nuttallornis borealis*					X	X	X	X
Vermillion flycatcher *Pyrocephalus rubinus*	X	X	X	X	X	X		X

Table A2.1.8.2-3 (Continued)

COMMON NAME Scientific Name	CC	Sonoran Desert CD(C)	YD	AUD	DG	Major Biomes[a] CD	TPDS	SGP
Beardless flycatcher *Camptostoma imberbe*			X	X	X			
Horned lark *Eremophila alpestris*	X	X	X	X		X		X
Violet-green swallow *Tachycineta thalassina*	X	X			X	X	X	
Tree swallow *Iridoprocne bicolor*	X		X	X		X	X	
Bank swallow *Riparia riparia*	X		X	X		X		X
Rough-winged swallow *Stelgidopteryx ruficollis*	X	X	X	X		X		X
Barn swallow *Hirundo rustica*	X		X	X	X	X	X	X
Cliff swallow *Petrochelidon pyrrhonota*	X		X	X	X	X	X	X
Cave swallow *P. fulva*						X	X	
Purple martin *Progne subis*	X			X	X			
Steller's jay *Cyanocitta stelleri*	X							
Scrub jay *Aphelocoma coerulescens*	X			X	X	X	X	X
Mexican jay *A. ultramarina*					X			
Common raven *Corvus corax*	X	X	X	X	X			
White-necked raven *C. cryptoleucus*	X			X		X	X	X
Common crow *C. brachyrhynchos*	X		X	X		X		X
Pinon jay *Gymnorhinus cyanocephalus*		X				X	X	
Plain titmouse *Parus inornatus*	X			X				
Bridled titmouse *P. wollweberi*				X				

Table A2.1.8.2-3 (Continued)

COMMON NAME Scientific Name	Major Biomes[a]							
		Sonoran Desert						
	CC	CD(C)	YD	AUD	DG	CD	TPDS	SGP
Verdin *Auriparus flaviceps*		X	X	X		X	X	X
Bushtit *Psaltriparus minimus*	X				X	X	X	X
White-breasted nuthatch *Sitta carolinensis*					X		X	
Red-breasted nuthatch *S. canadensis*					X	X	X	
Pygmy nuthatch *S. pygmea*					X			
Brown creeper *Certhia familiaris*					X		X	X
Wrentit *Chamaea fasciata*	X							
Dipper *Cinclus mexicanus*	X				X		X	
House wren *Troglodytes aedon*	X		X	X	X			X
Bewick's wren *Thryomanes bewickii*		X		X	X	X	X	X
Cactus wren *Campylorhynchus brunneicapillus*	X	X	X	X		X	X	X
Long-billed marsh wren *Telmatodytes palustris*	X		X			X		X
Canon wren *Catherpes mexicanus*	X	X		X	X	X	X	X
Rock wren *Salpinctes obsoletus*	X	X		X	X	X	X	X
Mockingbird *Mimus polyglottos*	X	X	X	X	X	X	X	X
Bendire's thrasher *Toxostoma bendirei*			X	X				
Curve-billed thrasher *T. curvirostre*			X	X		X		X
California thrasher *T. redivivum*	X							
Le Conte's thrasher *T. lecontei*		X	X					

Table A2.1.8.2-3 (Continued)

COMMON NAME Scientific Name	Major Biomes[a]							
		Sonoran Desert						
	CC	CD(C)	YD	AUD	DG	CD	TPDS	SGP
Crissal thrasher *T. dorsale*		X	X	X		X		
Sage thrasher *Oreoscoptes montanus*	X	X		X		X		X
American robin *Turdus migratorius*	X		X	X	X	X	X	X
Varied thrush *Ixoreus naevius*	X							
Hermit thrush *Catharus guttata*	X				X	X	X	X
Swainson's thrush *C. ustulatus*	X		X					X
Western bluebird *Sialia mexicana*	X				X	X	X	X
Mountain bluebird *S. currucoides*	X				X	X	X	X
Townsend's solitaire *Myadestes townsendi*					X	X	X	X
Golden-crowned kinglet *Regulus satrapa*					X			
Ruby-crowned kinglet *R. calendula*	X	X		X	X	X	X	X
Blue-gray gnatcatcher *Polioptila caerulea*	X	X			X			X
Black-tailed gnatcatcher *P. melanura*	X	X	X	X				
Water pipit *Anthus spinoletta*	X		X	X		X		X
Cedar waxwing *Bombycilla cedrorum*	X	X	X	X		X		X
Phainopepla *Phainopepla nitens*	X	X	X	X		X		
Loggerhead shrike *Lanius ludovicianus*	X	X	X	X	X	X	X	X
Starling *Sturnus vulgaris*	X	X	X	X		X		X
Hutton's vireo *Vireo huttoni*	X				X			

Table A2.1.8.2-3 (Continued)

COMMON NAME Scientific Name	Major Biomes[a] CC	Sonoran Desert CD(C)	 YD	 AUD	 DG	 CD	 TPDS	 SGP
Bell's vireo *V. bellii*	X		X	X	X			X
Gray vireo *V. vicinior*		X			X			
Solitary vireo *V. solitarius*					X	X	X	
Warbling vireo *V. gilvus*	X				X			
Black-and-white warbler *Mniotilta varia*	X	X		X		X		
Orange-crowned warbler *Vermivora celata*				X	X	X	X	X
Nashville warbler *V. ruficapilla*	X	X		X	X	X	X	X
Virginia's warbler *V. virginiae*					X			
Lucy's warbler *V. luciae*			X	X	X			
Yellow warbler *Dendroica petechia*	X			X	X	X	X	X
Yellow-rumped warbler *D. coronata*	X	X	X	X	X	X	X	X
Black-throated gray warbler *D. nigrescens*					X			
Townsend's warbler *D. townsendi*	X				X	X	X	
Hermit warbler *D. occidentalis*	X	X			X			
MacGillivray's warbler *Oporornis tolmiei*	X	X			X	X	X	X
Common yellowthroat *Geothlypis trichas*	X		X	X		X		X
Yellow-breasted chat *Icteria virens*	X		X	X	X	X	X	
Wilson's warbler *Wilsonia pusilla*	X		X	X		X		X
American redstart *Setophaga ruticilla*				X	X			X

Table A2.1.8.2-3 (Continued)

COMMON NAME Scientific Name		Major Biomes[a]						
		Sonoran Desert						
	CC	CD(C)	YD	AUD	DG	CD	TPDS	SGP
Painted redstart *S. picta*					X			
Eastern meadowlark *Sturnella magna*				X		X		X
Western meadowlark *S. neglecta*	X		X	X		X		X
House sparrow *Passer domesticus*	X	X	X	X		X		X
Yellow-headed blackbird *Xanthocephalus xanthocephalus*	X		X	X		X		X
Red-winged blackbird *Agelaius phoeniceus*	X		X	X	X	X	X	X
Tricolored blackbird *A. tricolor*	X							
Hooded oriole *Icterus cucullatus*	X		X	X	X			
Scott's oriole *I. parisorum*				X	X	X	X	
Northern oriole *I. galbula*	X		X	X		X		X
Brewer's blackbird *Euphagus cyanocephalus*	X			X	X	X	X	X
Great-tailed grackle *Cassidix mexicanus*				X		X		X
Brown-headed cowbird *Molothrus ater*	X		X	X		X		X
Bronzed cowbird *Tangavius aeneus*				X				
Western tanager *Piranga ludoviciana*	X	X		X	X	X	X	X
Hepatic tanager *P. flava*					X			
Summer tanager *P. rubra*				X	X	X	X	X
Cardinal *Cardinalis cardinalis*				X				X
Pyrrhuloxia *Pyrrhuloxia sinuata*			X	X		X		X

Table A2.1.8.2-3 (Continued)

COMMON NAME Scientific Name	CC	Sonoran Desert CD(C)	YD	AUD	DG	CD	TPDS	SGP
	Major Biomes[a]							
Black-headed grosbeak *Pheucticus melanocephalus*	X				X			X
Blue grosbeak *Guiraca caerulea*	X		X	X	X	X	X	X
Lazuli bunting *Passerina amoena*	X		X	X				
Varied bunting *P. versicolor*				X				
Painted bunting *P. ciris*								X
Evening grosbeak *Hesperiphona vespertina*					X	X	X	
Purple finch *Carpodacus purpureus*	X			X	X			
Cassin's finch *C. cassinii*					X			
House finch *C. mexicanus*	X	X	X	X		X		X
Pine siskin *Spinus pinus*	X			X		X		X
American goldfinch *S. tristis*	X		X	X		X		X
Lesser goldfinch *S. psaltria*	X			X	X	X	X	X
Lawrence's goldfinch *S. lawrencei*	X		X	X				
Green-tailed towhee *Chlorura chlorura*				X	X	X	X	X
Rufous-sided towhee *Pipilo erythrophthalmus*	X				X	X	X	X
Brown towhee *P. fuscus*	X			X	X	X	X	X
Abert's towhee *P. aberti*		X	X	X				
Lark bunting *Calamospiza melanocorys*				X		X		X
Savannah sparrow *Passerculus sandwichensis*	X		X	X		X		X

Table A2.1.8.2-3 (Continued)

COMMON NAME Scientific Name	Major Biomes[a] Sonoran Desert CC	 CD(C)	 YD	 AUD	 DG	 CD	 TPDS	 SGP
Arizona Grasshopper sparrow Ammodramus savannarum ammolequs				X	X			
Baird's sparrow A. bairdii						X		
Vesper sparrow Pooecetes gramineus					X	X	X	X
Lark sparrow Chondestes grammacus	X			X	X	X	X	X
Northern rufous-winged sparrow Aimophila carpalis carpalis			X	X				
Rufous-crowned sparrow A. ruficeps	X			X		X		X
Botteri's sparrow A. botterii botterii				X	X			
Cassin's sparrow A. cassinii				X				X
Black-throated sparrow Amphispiza bilineata		X	X	X	X			
Sage sparrow A. belli	X	X	X	X		X		
Dark-eyed junco Junco hyemalis	X		X	X	X	X	X	X
Gray-headed junco J. canciceps	X					X	X	
Mexican junco J. phaeonotus					X			
Chipping sparrow Spizella passerina	X	X			X	X	X	X
Clay-colored sparrow S. pallida						X		X
Brewer's sparrow S. breweri		X		X	X	X	X	
Black-chinned sparrow S. atroqularis	X	X		X				
Harris' sparrow Zonotrichia querula	X	X						
White-crowned sparrow Z. leucophrys	X	X	X	X	X	X	X	X

Table A2.1.8.2-3 (Continued)

COMMON NAME	Major Biomes[a]							
		Sonoran Desert						
Scientific Name	CC	CD(C)	YD	AUD	DG	CD	TPDS	SGP
Golden-crowned sparrow *Z. atricapilla*	X							
White-throated sparrow *Z. albicollis*			X	X				X
Fox sparrow *Passerella iliaca*	X	X						
Lincoln's sparrow *Melospiza lincolnii*	X		X	X		X		X
Song sparrow *M. melodia*	X		X	X		X		X
McCown's longspur *Calcarius mccownii*					X	X		X
Chestnut-collared longspur *C. ornatus*				X				

Table A2.1.8.2-4

Mammals Existing or Potentially Occurring Within Major Biomes

in the Vicinity of the Proposed Pipeline Route

COMMON NAME Scientific Name	Major Biomes[a] CC	Sonoran Desert CD(C)	 YD	 AUD	 DG	 CD	 TPDS	 SGP
Opossum *Didelphis marsupialis*	X	X			X	X	X	X
Vagrant shrew *Sorex vagrans*					X			
Ornate shrew *S. ornatus*	X	X						
Crawford's desert shrew *Notiosorex crawfordi*	X	X	X	X	X	X	X	X
Broad-footed mole *Scapanus latimanus*	X	X						
California leaf-nosed bat *Macrotus californicus*	X	X	X	X	X			
Mexican long-tongued bat *Choeronycteris mexicana*		X		X				
Sanborn's long-nosed bat *Leptonycteris nivalis sanborni*				X	X			
Yuma myotis *Myotis yumanensis*		X	X	X	X	X	X	X
Cave myotis *M. velifer*		X	X	X	X	X	X	X
Arizona myotis *M. occultus*		X	X	X		X		
Keen's myotis *M. keeni*					X			
Long-eared myotis *M. evotis*	X	X			X		X	

Source: Data modified from Hall and Kelson, 1959; Burt and Grossenheider, 1964; Ingles, 1965; Sargeant, 1966; Blair, 1968; Dengler and Dengler, 1972; Head, 1972; U.S. Bureau of Sport Fisheries and Wildlife, 1973; Leach, 1974; Pamphlet from Tucker Wildlife Sanctuary, Irvine, CA.

[a] Column abbreviations: CC, California Coastal; CD(C), Colorado Desert (California); YD, Yuman Desert; AUD, Arizona Upland Desert; DG, Desert Grassland; CD, Chihuahuan Desert; TPDS, Trans-Pecos Desert Scrub; SGP, Short-Grass Prairie.

Table A2.1.8.2-4 (Continued)

COMMON NAME Scientific Name	Major Biomes							
		Sonoran Desert						
	CC	CD(C)	YD	AUD	DG	CD	TPDS	SGP
Fringed myotis *M. thysanodes*	X	X			X		X	
Long-legged myotis *M. volans*	X	X			X		X	
California myotis *M. californicus*	X	X	X	X	X	X	X	
Small-footed myotis *M. subulatus*	X	X	X	X	X	X	X	X
Silver-haired bat *Lasionycteris noctivagans*					X		X	
Western pipistrelle *Pipistrellus hesperus*	X	X	X	X	X	X	X	X
Big brown bat *Eptesicus fuscus*	X	X	X	X	X	X	X	X
Red bat *Lasiurus borealis*	X	X			X		X	
Hoary bat *L. cinereus*	X	X			X		X	
Southern yellow bat *Dasypterus ega*	X	X		X	X			
Spotted bat *Euderma maculatum*	X	X		X	X	X		
Townsend's big-eared bat *Plecotus townsendii*	X	X			X		X	
Mexican big-eared bat *P. phyllotis*					X			
Pallid bat *Antrozous pallidus*	X	X	X	X	X	X	X	X
Brazilian free-tailed bat *Tadarida brasiliensis*	X	X	X	X	X	X	X	X
Pocketed free-tailed bat *T. femorosacca*	X	X	X	X				
Big free-tailed bat *T. molossa*	X	X	X	X		X		X
Greater mastiff bat *Eumops perotis*	X	X	X	X	X			
Black-tailed jackrabbit *Lepus californicus*			X	X		X	X	X

Table A2.1.8.2-4 (Continued)

COMMON NAME Scientific Name	Major Biomes CC	 Sonoran Desert CD(C)	 YD	 AUD	 DG	 CD	 TPDS	 SGP
Antelope jackrabbit *L. alleni*				X				
White-sided jackrabbit *L. callotis gaillardi*					X			
Eastern cottontail *Sylvilagus floridanus*					X		X	
Brush rabbit *S. bachmani*	X	X						
Desert cottontail *S. auduboni*	X	X	X	X	X	X	X	X
Cliff chipmunk *Eutamias dorsalis*					X		X	
Merriam's chipmunk *E. merriami*	X	X						
Lodgepole chipmunk *E. speciosus*	X	X						
Harris' antelope squirrel *Ammospermophilus harrisii*			X	X				
White-tailed antelope squirrel *A. leucurus*							X	
Mexican ground squirrel *Spermophilus mexicanus*						X	X	
California ground squirrel *S. beecheyi*	X	X						
Mohave ground squirrel *S. mohavensis*	X	X						
Spotted ground squirrel *S. spilosoma*				X		X		X
Rock squirrel *S. variegatus*			X	X		X	X	X
Round-tailed ground squirrel *S. tereticaudus*			X					
Arizona black-tailed prairie dog *Cynomys ludovicianus arizonensis*						X		X
Arizona gray squirrel *Sciurus arizonensis*					X			
Western gray squirrel *S. griseus*	X	X						

COMMON NAME Scientific Name	Major Biomes							
		Sonoran Desert						
	CC	CD(C)	YD	AUD	DG	CD	TPDS	SGP
Red squirrel S. hudsonicus					X		X	
Northern flying squirrel Glaucomys sabrinus	X	X						
Southern pocket gopher Thomomys umbrinus	X	X	X	X	X	X	X	
Bailey's pocket gopher T. baileyi					X			
Plains pocket gopher Geomys bursarius						X		X
Yellow-faced pocket gopher Cratogeomys castanops						X	X	X
Plains pocket mouse Perognathus flavescens								X
Merriam's pocket mouse P. merriami						X	X	X
Little pocket mouse P. longimembris	X	X						
Silky pocket mouse P. flavus				X		X		X
White-eared pocket mouse P. alticola	X	X						
Apache pocket mouse P. apache						X		
Long-tailed pocket mouse P. formosus	X	X						
Arizona pocket mouse P. amplus			X	X				
Bailey's pocket mouse P. baileyi		X	X	X		X		
Hispid pocket mouse P. hispidus						X		X
Desert pocket mouse P. penicillatus	X	X	X	X		X	X	
San Diego pocket mouse P. fallax	X	X						
California pocket mouse P. californicus	X	X						

Table A2.1.8.2-4 (Continued)

COMMON NAME Scientific Name	Major Biomes							
		Sonoran Desert						
	CC	CD(C)	YD	AUD	DG	CD	TPDS	SGP
Rock pocket mouse *P. intermedius*			X	X	X	X		
Nelson's pocket mouse *P. nelsoni*						X	X	
Spiny pocket mouse *P. spinatus*		X						
Ord's kangaroo rat *Dipodomys ordii*				X		X		X
Chisel-toothed kangaroo rat *D. microps*		X						
Banner-tailed kangaroo rat *D. spectabilis*				X		X		
Panamint kangaroo rat *D. panamintus*	X	X						
Stephens kangaroo rat *D. stephensi*	X	X						
Agile kangaroo rat *D. agilis*	X	X						
Merriam's kangaroo rat *D. merriami*	X	X	X	X		X		
Desert kangaroo rat *D. deserti*		X	X					
Plains harvest mouse *Reithrodontomys montanus*						X		X
Western harvest mouse *R. megalotis*	X	X	X	X	X	X	X	X
Fulvous harvest mouse *R. fulvescens*					X			
Canyon mouse *Peromyscus crinitus*			X					
California mouse *P. californicus*	X	X						
Cactus mouse *P. eremicus*	X	X	X	X	X	X	X	
Merriam's mouse *P. merriami*				X				
Deer mouse *P. maniculatus*	X	X	X	X	X	X	X	X

Table A2.1.8.2-4 (Continued)

COMMON NAME	Major Biomes							
		Sonoran Desert						
Scientific Name	CC	CD(C)	YD	AUD	DG	CD	TPDS	SGP
White-footed mouse *P. leucopus*				X	X	X	X	X
Brush mouse *P. boylii*	X	X			X	X	X	X
White-ankled mouse *P. pectoralis*						X	X	
Pinon mouse *P. truei*	X	X			X			
Zacatecan deer mouse *P. difficilis*						X	X	
Northern pygmy mouse *Baiomys taylori*				X				
Northern grasshopper mouse *Onychomys leucogaster*						X		X
Southern grasshopper mouse *O. torridus*	X	X	X	X		X		
Hispid cotton rat *Sigmodon hispidus*				X	X	X		X
Least cotton rat *S. minimus*						X		
Yellow-nosed cotton rat *S. ochrognathus*					X			
Southern Plains wood rat *Neotoma micropus*						X	X	X
White-throated wood rat *N. albigula*			X	X		X		X
Desert wood rat *N. lepida*			X					
Mexican wood rat *N. mexicana*					X		X	
Dusky-footed wood rat *N. fuscipes*	X	X						
Mexican vole *Microtus mexicanus*					X		X	
California vole *Microtus californicus*	X	X						
Muskrat *Ondatra zibethicus*						X	X	

Table A2.1.8.2-4 (Continued)

COMMON NAME Scientific Name	Major Biomes CC	Sonoran Desert CD(C)	 YD	 AUD	 DG	 CD	 TPDS	 SGP
Black rat *Rattus rattus*	X	X						
Norway rat *R. norvegicus*	X	X	X	X		X		X
House mouse *Mus musculus*	X	X	X	X		X		X
Porcupine *Erethizon dorsatum*		X			X		X	
Beaver *Castor canadensis*		X						
Coyote *Canis latrans*	X	X	X	X	X	X	X	X
Kit fox *Vulpes macrotis*	X	X	X	X	X	X	X	
Swift fox *V. velox*								X
Gray fox *Urocyon cinereoargenteus*	X	X	X	X	X	X	X	
Black bear *Ursus americanus*					X			
Ringtail *Bassariscus astutus*	X	X	X	X	X	X	X	X
Raccoon *Procyon lotor*	X	X	X	X	X	X	X	X
Coatimundi *Nasua narica*					X			
Long-tailed weasel *Mustela frenata*	X	X			X	X	X	X
Black-footed ferret *M. nigripes*			X	X	X	X	X	X
Badger *Taxidea taxus*	X	X	X	X		X		X
Eastern spotted skunk *Spilogale putorius*			X	X	X	X	X	X
Western spotted skunk *S. gracilis*	X	X						
Striped skunk *Mephitis mephitis*	X	X	X	X	X	X	X	X

COMMON NAME Scientific Name	Major Biomes							
		Sonoran Desert						
	CC	CD(C)	YD	AUD	DG	CD	TPDS	SGP
Hooded skunk M. macroura				X	X	X	X	X
Eastern hog-nosed skunk Conepatus leuconotus				X	X	X	X	
River otter Lutra canadensis		X						
Mountain lion Felis concolor	X	X		X	X	X		
Jaguarundi F. yagouaroundi			X	X	X	X	X	
Jaguar F. onca			X	X	X	X	X	
Ocelot F. pardalis			X	X	X	X	X	
Bobcat Lynx rufus	X	X	X	X	X	X	X	X
Collared peccary Tayassu tajacu				X	X	X	X	
Mule deer Odocoileus hemionus	X	X		X	X	X	X	
White-tailed deer O. virginiana					X		X	
Pronghorn Antilocarpa americana	X	X		X		X		X
California bighorn sheep Ovis canadensis californicus		X						
Desert bighorn sheep O. c. nelsoni			X	X	X			

Table A2.1.8.2-5

Fishes Existing or Potentially Occurring

in the Vicinity of the Proposed Pipeline Route

COMMON NAME Scientific Name	Aquatic Systems[a] Lower Colorado River	Lower Gila River	San Pedro River	Upper Rio Grande	Lower Pecos River
Longnose gar *Lepisosteus osseus*					X
Machete *Elops affinis*	X				
Gizzard shad *Dorosoma cepedianum*					X
Threadfin shad *D. petenense*	X	X			X
Mexican tetra *Astyanax mexicanus*	X?				X
Carp *Cyprinus carpio*	X	X			X
Utah chub *Gila atraria*	X?				
Leatherside chub *G. copei*	X?				
Bonytail chub *G. elegans*	X				
Rio Grande chub *G. nigrescens*	X?				
White River spinedace *Lepidomeda albivallis*	X?				
Virgin spinedace *L. mollispinis*	X?				
Golden shiner *Notemigonus crysoleucas*	X				

Source: Data modified from Coleman, 1926; Miller, 1952; Shapovalov and Dill, 1959; Moore, 1968; U.S. Bureau of Sport Fisheries and Wildlife, 1973; Nicola, 1974. Nomenclature by Bailey et al., 1970.

[a] Key to entries: X, present; D, dubious record; ?, valid record but species probably not breeding, hence may no longer be present.

Table A2.1.8.2-5 (Continued)

COMMON NAME Scientific Name	Aquatic Systems Lower Colorado River	Lower Gila River	San Pedro River	Upper Rio Grande	Lower Pecos River
Spikedace *Meda fulgida*		X	X		
Speckled dace *Rhinichthys osculus*	X		X		
Redside shiner *Richardsonius balteatus*	X?				
Longfin dace *Agosia chrysogaster*	X?	X			
Loach minnow *Tiaroga cobitis*		X			
Red shiner *Notropis lutrensis*	X	X			X
Proserpine shiner *N. proserpinus*				X	X
Silvery minnow *Hybognathus nuchalis*					X
Colorado squawfish *Ptychocheilus lucius*	X				
Fathead minnow *Pimephales promelas*	X	X			X
Black buffalo *Ictiobus niger*					X
Smallmouth buffalo *I. bubalus*					X
Gray Redhorse *Moxostoma congestum*					X
River carpsucker *Carpiodes carpio*					X
Utah sucker *Catostomus ardens*	X?				
White sucker *C. commersoni*	X?				
Bluehead sucker *C. discobolus*	X?				
Sonora sucker *C. insignis*		X			X
Flannelmouth sucker *C. latipinnis*	X				

Table A2.1.8.2-5 (Continued)

COMMON NAME Scientific Name	Aquatic Systems Lower Colorado River	Lower Gila River	San Pedro River	Upper Rio Grande	Lower Pecos River
Mountain sucker *C. platyrhynchus*	X?				
Rio Grande sucker *C. plebius*	X?				
Desert sucker *C. clarki*	X	X			
Humpback sucker *Xyrauchen texanus*	X				
Channel catfish *Ictalurus punctatus*		X		X	X
Flathead catfish *Pylodictis olivaris*				X	X
Desert pupfish *Cyprinodon macularius*	X				
Pecos River pupfish *C.* spp.					X
Rio Grande killifish *Fundulus zebrinus*	X?				X
Rainwater killifish *Lucania parva*				X	X
Sailfin molly *Poecilia latipinna*		X			
Mosquitofish *Gambusia affinis*	X	X	X	X	X
Pecos gambusia *G. nobilis*					X
Topsmelt *Atherinops affinis*	X				
Gila topminnow *Poeciliopsis occidentalis*		X			
Tidewater silverside *Menidia beryllina*					X
White bass *Morone chrysops*					X
Largemouth bass *Micropterus salmoides*		X	X		X
Green sunfish *Lepomis cyanellus*	X	X	X		X

Table A2.1.8.2-5 (Continued)

COMMON NAME Scientific Name	Aquatic Systems Lower Colorado River	 Lower Gila River	 San Pedro River	 Upper Rio Grande	 Lower Pecos River
Bluegill *L. macrochirus*	X	X	X		X
Redear sunfish *L. microlophus*	X				
Big scale logperch *Percina macrolepida*					X
Greenthroat darter *Etheostoma lepidum*					X
Spotted sleeper *Eleotris picta*	X				
Mozambique mouthbrooder *Tilapia mossambica*		X			

Appendix 2.1.8.2

1. Bailey, R.M., J.E. Fitch, E.S. Herald, E.A Lachner, C.C. Lindsey, C.R. Robbins, and W.B. Scott. 1970. A List of the Common and Scientific Names of Fishes from the United States and Canada. 3rd ed. Amer. Fish. Soc. Spec. Publ. No. 6.

2. Blair, A.P. 1968. Amphibians. In W.F. Blair, et al., Vertebrates of the United States. 2nd ed. McGraw-Hill Book Co., New York, N.Y.

3. Brode, J.M. 1974. Reptiles. In At the Crossroads. Calif. Dept. Fish and Game, Sacramento.

4. Burt, W.H. and R.P. Gorssenheider. 1964. A Field Guide to the Mammals. Houghton Mifflin Co., Boston, Mass.

5. Cagle, F.R. 1968. Reptiles. Pages 214-260 in W.F. Blair, et al., Vertebrates of the United States. 2nd ed. McGraw-Hill Book Co., New York, N.Y.

6. Coleman, G.A. 1926. A Biological Survey of the Salton Sea. Calif. Fish and Game 15:218-227.

7. Dengler, W.F., and S. Dengler. 1972. Mammals of Joshua Tree National Monument. U.S. Nat. Park Serv.

8. Hall, E.R., and K.R. Kelson. 1959. The Mammals of North America. Ronald Press, New York, N.Y.

9. Head, W.S. 1972. The California Chaparral, an Elfin Forest. Naturegraph Publ., Healdsburg, Calif.

10. Ingles, L.G. 1965. Mammals of the Pacific States. Stanford Univ. Press.

11. Lane, J.A. 1971. A Birder's Guide to Southern California. L. and P. Photo Co., Sacramento, Calif.

12. Leach, H.R. 1974. Mammals. In At the Crossroads. Calif. Dept. Fish and Game, Sacramento.

13. Mayhew, W.W., J. Zabriskie, C. Wainwright, and W. Wirtz. 1974. Bird List for Boyd Center and Deep Canyon Transect. Univ. Calif., Riverside.

14. Miller, R.R. 1952. Bait Fishes from the Lower Colorado River from Lake Mead, Nevada, to Yuma, Arizona, with a key for their Identification. Calif. Fish Game 38:7-42.

15. Moore, G.A. 1968. Fishes. Pages 21-165 in W.F. Blair, et al., Vertebrates of the United States. 2nd ed. McGraw-Hill Book Co., New York, N.Y.

16. Nicola, S.J. 1974. Fishes. In At the Crossroads. Calif. Dept. Fish and Game, Sacramento.

17. Peterson, R.T. 1969. A Field Guide to Western Birds. Houghton Mifflin Co., Boston, Mass.

Appendix 2.1.8.2 (Continued)

18. Pyle, R.L. and A. Small. 1961. Birds of Southern California: Annotated Field List. Otis Wade, Los Angeles.

19. Robbins, C.S., B. Brunn, and H.S. Zinn. 1966. Birds of North America. Golden Press, New York, N.Y.

20. Sargeant, R.B. 1966. The Mammals, Amphibians, Reptiles Anza-Borrego Desert State Park. Calif. Dep. Parks Recreation, Sacramento, Calif.

21. Shapovalov, L., and W.A. Dill. 1959. A Revised Checklist of the Fresh-water and Anadromous Fishes of California. Calif. Fish Game 45:159-180.

22. Stebbins, R.C. 1966. A Field Guide to Western Reptiles and Amphibians. Houghton Mifflin Co., Boston, Mass.

23. U.S. Bureau of Sport Fisheries and Wildlife. 1973. Threatened Wildlife of the United States. Office of Endangered and International Activities, U.S. Dept. Interior. Resourc. Publ. 114.

APPENDIX A2.1.8.3

Threatened, Rare, Endangered, or Protected Species

Along the Sea Leg and the Proposed Pipeline Route

Table A2.1.8.3-1

Threatened, Rare, and Endangered Marine Mammals Along the Sea Leg

SPECIES	Estimated World Population and Trend[a]		Status[b] State	Status[b] Federal	Location
1. Guadalupe fur seal Arcto cephalus townsendi	2 to 5 (Calif.) 600 (Mexico)	Slowly increasing	R		San Miguel Is., Calif., Guadalupe Is., Mexico
2. California sea otter Enlyra lutris nereis	1,700	Increasing		T	Central Calif. coast
3. Gray Whale Eschrichtius gibbosus	11,000	Stable		E	Offshore West Coast -- Oceanic
4. Blue whale Balaenoptera musculus	8,600	Declining		E	Offshore West Coast -- Oceanic
5. Finback whale Balaenoptera musculus	97,000 to 100,000	Declining		E	Offshore West Coast -- Oceanic
6. Sei whale Balaenoptera borealis	115,000	Stable-declining		E	Offshore West Coast -- Oceanic
7. Humpback whale Megaptera novaeangilae	5,200	Stable		E	Offshore West Coast -- Oceanic
8. Pacific right whale Balaena glacialis	4,550	Stable		E	Offshore West Coast -- Oceanic
9. Sperm whale Physeter catoden	699,000	Stable		E	Offshore West Coast -- Oceanic
10. Bowhead whale Balaena mysticetus	Unknown	Unknown		E	Offshore West Coast -- Oceanic

[a] National Marine Fisheries Service. Federal Register, Vol. 40, No. 141, Tuesday, 22 July 1975.

[b] Column abbreviations: R, Rare; T, Threatened; E, Endangered.

Table A2.1.8.3-2

Rare and Endangered Species of

Birds Along the Sea Leg

	SPECIES	Population Trend	Status[a] State	Federal	Location
1.	Light-footed clapper rail *Rallus longirastris levipes*	Declining; loss of habitat	E	E	Southern California
2.	Aleutian Canada goose *Branta Canadensis leucopareia*	Increasing; recovery team efforts		E	North Coast
3.	American peregrine falcon *Falco peregrinus anatum*	Increasing; protection; regulation of DDT use	E	E	California
4.	Southern bald eagle *Haliaeetus l. leucocephalus*	Decreasing; illegal hunting; loss of nest trees	E	E	South of 40th parallel
5.	California brown pelican *Pelecanus occidentalis californicus*	Increasing; protection; regulation of DDT use	E	E	San Francisco area, Big Sur & So. Calif.
6.	California least tern *Sterna albifrons browni*	Increasing; protection	E	E	San Francisco, Big Sur and So. Calif. areas
8.	Beldings Savannah sparrow *Passesculus sandwichensis beldingi*	Unknown. Presently being studied.	E		Southern California

[a] Column abbreviations: E, Endangered; R, Rare.

Table A2.1.8.3-2 (Continued)

SPECIES	Population Trend	Status State	Status Federal	Location
9. California black rail *Laterallus jamaiceusis coturniculus*	Declining; loss of habitat	R		San Francisco area, Southern California
11. Short-tailed albatross *Diomedea albatrus*			E	Gulf of Alaska, Oceanic waters
12. Santa Barbara sparrow *Melospiza melodra gaminea*		Extinct	E	California

Table A2.1.8.3-3

Rare, Threatened, Endangered, and/or Protected Vertebrates Which May Occur in the Vicinity of the Proposed Pipeline Route

COMMON NAME / Scientific Name	Status and Authority[a]					
	U.S. Dept. Int.	CA	AZ	NM	Texas State	Texas TOES[b]
Fishes						
Spikedace *Meda fulgida*			T[c]	T		
Beautiful shiner *Notropis formosus*				E		
Proserpine shiner *N. proserpinus*				E		
Pecos pupfish *Cyprinodon* spp.				T		
Rainwater killifish *Lucania parva*				T		
Pecos gambusia *Gambusia nobilis*	E			E		T
Gila topminnow *Poeciliopsis occidentalis*	E			E		
Greenthroat darter *Etheostoma lepidum*				T		
Big scale logperch *Percina macrolepida*				T		
Bonytail chub *Gila elegans*		R				

Source: Data modified from U.S. Fish and Wildlife Service, 1976; Bureau of Sport Fisheries and Wildlife, 1973; California Dept. of Fish and Game, 1976; Arizona Game and Fish Dept., 1976; New Mexico State Game Commission, 1976; Texas Parks and Wildlife Dept., 1976; Texas Organization for Endangered Species, 1975; and sources cited in Section 2.1.8.3 of the text.

[a] Status is presented by authority which determined status.

[b] TOES (Texas Organization for Endangered Species).

[c] Column Abbreviations: E, Endangered; F, Fully Protected; P, Peripheral; R, Rare; S, Special Protection; T, Threatened.

Table A2.1.8.3-3 (Continued)

COMMON NAME Scientific Name	Status and Authority U.S. Dept. Int.	CA	AZ	NM	Texas State	TOES
Fishes (continued)						
Colorado squawfish *Ptychocheilus lucius*	E	E/F				
Humpback sucker *Xyrauchen texanus*		R/F				
Amphibians						
Great Plains narrow-mouthed toad *Gastrophryne olivacea*			T			
Colorado river toad *Bufo alvarius*				T		
Eastern barking frog *Eleutherodactylus augusti latrans*			T	T		
Blanchard's cricket frog *Acris crepitans blanchardi*				T		
Burrowing treefrog *Pternohyla fodiens*			T			
Reptiles						
Texas slider *Pseudemys concinna texana*				T		
Desert tortoise *Gopherus agassizi*		S	T			
Sagebrush lizard *Sceloporus graciosus arenicolous*				T		
Gila monster *Heloderma suspectum*			T	E		
Giant spotted whiptail *Cnemidophorus burti stictogrammu*				T		
Desert rosy boa *Lichanura trivirgata garcia*			T			
Southern rubber boa *Charina bottae*		R				
Blotched water snake *Natrix erythrogaster transversa*				T		

Table A2.1.8.3-3 (Continued)

COMMON NAME Scientific Name	Status and Authority U.S. Dept. Int.	CA	AZ	NM	Texas State	TOES
Reptiles (continued)						
Pecos ribbon snake *Thamnophis proximus diabolicus*				T		
Sonora coachwhip *Masticophis flagellum cingulum*				T		
Western hook-nosed snake *Ficima cana*			T			
Arizona coral snake *Micruroides euryxanthus euryxanthus*				T		
Massasauga *Sistrurus catenatus*			T			
Mottled rock rattlesnake *Crotalus lepidus lepidus*				T		
Banded rock rattlesnake *C. l. klauberi*			T			
Mojave rattlesnake *C. scutulatus scutulatus*				T		
Birds						
Olivaceous cormorant *Phalacrocorax olivaceus*				T		P
Black-crowned night heron *Nycticorax nycticorax*			T			
Great egret *Casmerodius albus*			T			
Snowy egret *Egretta thula*			T			
Brown pelican *Pelecanus occidentalis*	E	E				
Black-bellied tree duck *Dendrocygna autumnalis*			T			
Mexican duck *Anas diazi*	E		T	E	E	E
Mississippi kite *Ictinia misisippiensis*			E	T		

Table A2.1.8.3-3 (Continued)

COMMON NAME Scientific Name	Status and Authority U.S. Dept. Int.	CA	AZ	NM	Texas State	TOES
Birds (continued)						
White-tailed kite *Elanus leucurus*		F				
Gray hawk *Buteo nitidus*			E			P
Zone-tailed hawk *B. albonotatus*			T			P
White-tailed hawk *B. albicaudatus*						P
Black hawk *Buteogallus anthracinus*			T	T		P
Southern bald eagle *Haliaeetus leucocephalus leucocephalus*	E	E/F	E	E	E	E
Osprey *Pandion haliaetus*			T	T		E
Prairie falcon *Falco mexicanus*						T
Peregrine falcon *F. peregrinus anatum*	E	E/F	E	E	E	
Aplomado falcon *F. femoralis*			E	E		
Merlin *F. columbarius*						T
Yuma clapper rail *Ralius longirostris yumanensis*	E	E/F	E			
California black rail *Laterallus jamaicensis coturniculus*		R/F	E			
California least tern *Sterna albifrons browni*	E	E/F				
California yellow-billed cuckoo *Coccyzus americanus occidentalis*		R				
Ferruginous owl *Glaucidium brasilianum*						P
Whip-poor-will *Caprimulgus vociferus*				T		

Table A2.1.8.3-3 (Continued)

COMMON NAME / Scientific Name	Status and Authority: U.S. Dept. Int.	CA	AZ	NM	Texas: State	Texas: TOES
Birds (continued)						
Broad-billed hummingbird *Cynanthus latirostris*				T		
Gila woodpecker *Centurus uropygialis uropygialis*				T		
Rose-throated becard *Platypsaris aglaiae*			E			P
Thick-billed kingbird *Tyrannus crassirostris pompalis*			T	T		
Buff-breasted flycatcher *Empidonax fulvifrons pygmaeus*			E	E		
Beardless flycatcher *Camptostoma imberbe ridgwayi*				T		P
Bell's vireo *Vireo bellii*				T		
Varied bunting *Passerina versicolor*				T		
McCown's longspur *Calcarius mccownii*				T		
Baird's sparrow *Ammodramus bairdii*				T		
Botteri's sparrow *Aimophila botterii botterii*						P
Mammals						
Sanborn's long-nosed bat *Leptonycteris nivalis sanborni*				T		P
Southern yellow bat *Dasypterus ega xanthinus*				E		P
Spotted bat *Euderma maculatum*						T
White-sided antelope jackrabbit *Lepus callotis gaillardi*				E		
Mohave ground squirrel *Spermophilus mohavensis*		R				
Stephens kangaroo rat *Dipodomys stephensi*		R				

Table A2.1.8.3-3 (Continued)

COMMON NAME Scientific Name	Status and Authority U.S. Dept. Int.	CA	AZ	NM	Texas State	TOES
Mammals (continued)						
Arizona black-tailed prairie dog *Cynomys ludovicianus arizonensis*			E	T		
Southern pocket gopher *Thomomys umbrinus emotus*				T		
Swift fox *Vulpes velox*	E					T
Kit fox *V. macrotis*		S				
Coatimundi *Nasua narica molaris*				T		
Ringtail *Bassariscus astutus*		F				
Black-footed ferret *Mustela nigripes*	E		E	E	E	E
Jaguar *Felis onca arizonensis*	E			E		
Ocelot *F. pardalis*	E				E	P
Yuma mountain lion *F. concolor browni*			E			E
Jaguarundi *F. yagouaroundi tolteca*	E					P
Mexican pronghorn *Antilocarpa americana mexicana*			T			
Sonoran pronghorn *A. a. sonoriensis*			T			
Desert bighorn sheep *Ovis canadensis nelsoni*			T		E	
California bighorn sheep *O. c. californiana*		R/F				

Appendix 2.1.8.3

1. Arizona Department of Fish and Game. 1976. Threatened Wildlife of Arizona. Ariz. Dept. Fish and Game. Mimeographed.

2. California Dept. of Fish and Game. 1976. Status Designation of California Vertebrates.

3. New Mexico State Game Commission. 1976. New Mexico List of Endangered Species and Subspecies. N. Mex. State Game Comm. Reg. 563. New Mexico Dept. of Game and Fish.

4. Texas Organization for Endangered Species (TOES). 1975. TOES Watchlist of Endangered, Threatened, and Peripheral Vertebrates of Texas. Tex. Organ. Endangered Species, Publ. 1.

5. Texas Parks and Wildlife Department. 1976. Regulations for Taking, Possessing, Transporting, Exporting, Processing, Selling or Offering for Sale, or Shipping of Endangered Species.

6. U.S. Fish and Wildlife Service. 1976. Endangered and Threatened Wildlife and Plants, Federal Register. U.S. Government Printing Office, Washington, D.C.

APPENDIX A2.1.9.3

Recorded Archaeological Resources in California Pipeline Route

Table A2.1.9.3-1

Recorded Archaeological Resources Along Pipeline Route in California

USGS QUAD MAP NUMBER	Designation		Location
7.5 Long Beach	LAn	389	E of Dominguez Hills, W Alameda, N Del Amo
	LAn	390	S of Dominguez Hills, W Alameda, NE of Arroyo
7.5 Whittier	LAn	182A	Pioneer Blvd. Area of Pio Pico St. Hist. Monument
	LAn	182C	Millergrove and Broaded St. Santa Fe Springs
7.5 Baldwin Park	LAn	136	Corner Baldwin Park Ave. and Railroad Ave.
7.5 La Habra	LAn	179	WNW corner Nogales and Railroad St. City of Industry
7.5 San Dimas	LAn	521	.5 mi. NNE La Puente and Lemon Rd. junction
	LAn	522	Sec. 4, T. 2 S., R. 9 W.
	LAn	346	E side of Garey, N of Reno
	SBCM	3025	Adjacent Valley Blvd.,
	SBCM	3025	T. 1 S., R. 9 W., SW of trailer park
7.5 Fontana	SBCM	2456	Sec. 31, T. 1 S., R. 5 W.
	SBCM	6	Sec. 29, T. 1 S., R. 5 W.
	SBCM	2457	Sec. 31, T. 1 S., R. 5 W.
	SBCM	5	Sec. 33, T. 1 S., R. 5 W.
	SBCM	7	Sec. 31, T. 1 S., R. 5 W.
	SBCM	2455	Sec. 32, T. 1 S., R. 5 W.
	SBCM	2453	Sec. 32, T. 1 S., R. 5 W.
	SBCM	2454	Sec. 5, T. 1 S., R. 5 W.
	SBCM	3025	Sec. 28, T. 1 S., R. 5 W.
	SBr	714(A-C)	Sec. 33, T. 1 S., R. 5 W.
	SBr	715	Sec. 33, T. 1 S., R. 5 W.
	RIv	799	Sec. 1, T. 2 S., R. 6 W.
	RIv	615	Sec. 1, T. 2 S., R. 6 W.
	RIv	616	Sec. 1, T. 2 S., R. 6 W.
	RIv	617A,B	Sec. 1, T. 2 S., R. 6 W.
	RIv	618	Sec. 1, T. 2 S., R. 6 W.
	RIv	674	Sec. 7, T. 2 S., R. 5 W.
	RIv	502	Sec. 12, T. 2 S., R. 6 W.
	SBCM	1256	Sec. 7, T. 2 S., R. 5 W.
7.5 San Bernardino South	SBCM	10	Sec. 16, T. 1 S., R. 4 W.
	SBCM	115	Sec. 16, T. 1 S., R. 4 W.
	SBCM	437	Colton Ave. and J. St. Colton
	SBCM	190	Sec. 21, T. 1 S., R. 4 W.
	SBCM	11	Sec. 27, T. 1 S., R. 4 W.
	SBCM	40	Slover Mountain quarry
	SBCM	622	Sec. 11, T. 1 S., R. 4 W.
	SBCM	34	Sec. 30, T. 1 S., R. 4 W.
	SBCM	2244	Sec. 31, T. 1 S., R. 4 W.

Table A2.1.9.3-1 (Continued)

USGS QUAD MAP NUMBER	Designation		Location
7.5 Redlands	SBCM	157	Mission Rd. and Mt. View, Bryn Mawr
	SBCM	9	Sec. 10, T. 2 S., R. 3 W.
	SBCM	9	Sec. 13, T. 2 S., R. 3 W.
7.5 El Casco	RIv	179	Sec. 20, T. 2 S., R. 2 W.
	RIv	790	San Timoteo Canyon Road, Cal. 2 mi. SE El Casco
	RIv	794	San Timoteo Canyon Road, Cal. 3 mi. SE El Casco
	SBCM	280	Sec. 26, T. 2 S., R. 2 W.
	SBCM	281	Sec. 6, T. 3 S., R. 1 W
7.5 Beaumont	RIv	99	Sec. 4, T. 3 S., R. 1 E.
	RIv	254	Sec. 16, T. 3 S., R. 1 E.
	RIv	190	Sec. 21, T. 3 S., R. 1 E.
	V-DV	4	Sec. 21, T. 3 S., R. 1 E.
7.5 Cabazon	RIv	199	Sec. 31, T. 2 S., R. 2 E.
	RIv	173	Sec. 36, T. 2 S., R. 1 E.
	RIv	84	Sec. 33, T. 2 S., R. 2 E.
	RIv	172	Sec. 36, T. 2 S., R. 1 E.
	RIv	174	Sec. 36, T. 2 S., R. 1 E.
	RIv	85	Sec. 34, T. 2 S., R. 2 E.
	RIv	57	Sec. 14, T. 3 S., R. 1 E.
	RIv	185	Sec. 21, T. 3 S., R. 2 E.
	RIv	317	Sec. 32, T. 2 S., R. 2 E.
	RIv	372	Hargrave and S city boundary of Banning
	RIv	373	Wesley and Hathaway, Banning
	RIv	197	Sec. 34, T. 2 S., R. 1 E.
7.5 White Water	RIv	74	Sec. 36, T. 2 S., R. 2 E.
	RIv	73	Sec. 32, T. 2 S., R. 3 E.
	RIv	75	Sec. 34, T. 2 S., R. 3 E.
	RIv	8	Sec. 13, T. 3 S., R. 3 E.
	RIv	178	Sec. 14, T. 3 S., R. 3 E.
	RIv	83	Sec. 29, T. 3 S., R. 3 E.
	RIv	82	Sec. 29, T. 3 S., R. 3 E.
	RIv	187	Sec. 23, T. 3 S., R. 2 E.
7.5 Desert Hot Springs	RIv	154	Sec. 18, T. 3 S., R. 5 E.
	RIv	198	Sec. 22, T. 3 S., R. 5 E.
15.0 Palm Springs	RIv	118	Sec. 1, T. 3 S., R. 3 E.
7.5 Seven Palms Valley	RIv	58	Sec. 21, T. 3 S., R. 5 E.
7.5 Cathedral City	RIv	9?	Sec. 36, T. 3 S., R. 5 E.
	RIv	9?	Sec. 6, T. 4 S., R. 6 E.
	RIv	9?	Sec. 5, T. 4 S., R. 6 E. (Also, unrecorded National Register candidate)

<u>Table A2.1.9.3-1</u> (Continued)

USGS QUAD MAP NUMBER	Designation		Location
7.5 Myoma	RIv	53T	Sec. 11, T. 4 S., R. 6 E.
	RIv	53T	Sec. 12, T. 4 S., R. 6 E.
	RIv	56	Sec. 1, T. 4 S., R. 6 E.
	RIv	56	Sec. 12, T. 4 S., R. 6 E.
	RIv	334	Sec. 7, T. 4 S., R. 7 E.
	RIv	336	Sec. 7, T. 4 S., R. 7 E.
	RIv	335	Sec. 7, T. 4 S., R. 7 E.
	RIv	51	Sec. 13, T. 4 S., R. 6 E.
	Riv	54	Sec. 18, T. 4 S., R. 7 E.
	RIv	87	Sec. 14, T. 4 S., R. 6 E.
	RIv	266	Sec. 17, T. 4 S., R. 7 E.
	RIv	363	Sec. 18, T. 4 S., R. 7 E.
	RIv	252	Sec. 24, T. 4 S., R. 6 E.
	RIv	63	Sec. 19, T. 5 S., R. 6 E.
	RIv	267	Sec. 28, T. 4 S., R. 7 E.
	RIv	183	Trail through,
	RIv	183	Sec. 28, T. 4 S., R. 7 E.
	RIv	149	Indio and environs
	RIv	387	Sec. 28, T. 4 S., R. 7 E.
7.5 La Quinta	RIv	149	Town of Indio and environs
15.0 Lost Horse Mtn.	RIv	183T	Sec. 28, T. 4 S., R. 7 E.
	RIv	183T	Sec. 22, T. 4 S., R. 7 E.
	RIv	183T	Sec. 14, T. 4 S., R. 7 E.
	RIv	196T	Sec. 22, T. 4 S., R. 7 E.
	RIv	196T	Sec. 23, T. 4 S., R. 7 E.
	RIv	164	Sec. 34, T. 4 S., R. 7 E.
	RIv	164	Sec. 35, T. 4 S., R. 7 E.
	RIv	163	Sec. 2, T. 5 S., R. 7 E.
	RIv	149	Town of Indio and environs
7.5 Indio	RIv	159	Sec. 21, T. 5 S., R. 8 E.
	RIv	135	Sec. 29, T. 6 S., R. 7 E.
	RIv	149	Town of Indio and environs
15.0 Cotton-wood Spring	RIv	193T	Trail,
	RIv	193T	Sec. 29, T. 6 S., R. 11 E.
	RIv	250T	Trail,
	RIv	250T	Sec. 36, T. 5 S., R. 9 E.
	V-PL	3T	Trail,
	V-PL	3T	Sec. 8, T. 6 S., R. 10 E.
	V-PL	3T	Sec. 5, T. 6 S., R. 10 E.
15.0 Hayfield	RIv	76	Hayfield Spring area,
	RIv	76	T. 5 S., R. 13 E.
	RIv	49	Sec. 22, T. 5 S., R. 14 E.
	RIv	241	Hayfield Spring area. SBCM 1257-1274 National Register Candidate
	V-PL	1	Adjacent,
	V-PL	1	Sec. 9, T. 6 S., R. 13 E.
	V-PL	2	Sec. 14, T. 6 S., R. 12 E.
	RIv	43	Sec. 35, T. 5 S., R. 12 E.
15.0 Chuckwalla Mountains	RIv	72	Sec. 25, T. 5 S., R. 14 E.
	RIv	72	Sec. 26, T. 5 S., R. 14 E.

Table A2.1.9.3-1 (Continued)

USGS QUAD MAP NUMBER	Designation		Location
15.0 Side-winder Well	RIv	343T	Sec. 34, T. 6 S., R. 18 E.
	RIv	343T	Sec. 35, T. 6 S., R. 18 E.
	RIv	343T	Sec. 36, T. 6 S., R. 18 E.
	RIv	343T	Sec. 31, T. 6 S., R. 18 E.
	RIv	343T	Sec. 32, T. 6 S., R. 18 E.
	RIv	343T	Sec. 33, T. 6 S., R. 18 E.
15.0 McCoy Spring	RIv	260	Sec. 32, T. 6 S., R. 20 E.
	RIv	261	Sec. 32, T. 6 S., R. 20 E.
	RIv	259	Sec. 33, T. 6 S., R. 20 E.
	RIv	257	Sec. 32, T. 6 S., R. 21 E.
	RIv	663	Sec. 30, T. 6 S., R. 20 E.
			Additional designation EMH-3
			Clustered petroglyph sites, N end Mule Mountains, candidate for National Register

APPENDIX A2.1.12.6

Land Uses and Special Features

Along the Proposed Pipeline Route

Table A2.1.12.6-1

Special Features Within the Proposed Pipeline Corridor,

San Pedro Bay to Pomona

FEATURE	Proximity to the Proposed Pipeline Route (Approx. Miles)
Port of Long Beach to flood control basin	
Queen Mary	0.2
Navy landing	Adjacent
Palm Beach Park	Adjacent
Edison School	0.1
Drake School	0.1
Garfield School	0.3
Muir School	0.3
Birney School	0.2
Los Cerritos Park	0.2
Los Cerritos School	0.2
Country club	Adjacent
Oil sump	Adjacent
Union School	Adjacent
Sutter School	Adjacent
Country club	Adjacent
Coolidge Park	0.1
Houghton Park	0.3
Jordon High School	0.2
Houghton Park	Adjacent
Grant School	0.3
Ramona Park	0.3
Jordon High School	0.3
Dominguez High School	0.1
Golf course	Adjacent
Los Cerritos School	0.3

Table A2.1.12.6-1 (Continued)

FEATURE	Proximity to the Proposed Pipeline Route (Approx. Miles)
Lugo Park	0.2
Will Rogers School	Adjacent
Grove School	0.3
Hollydale School	0.2
Golf course	0.2
Los Padrinos juvenile hall	0.2
John A. Ford Park	Adjacent
Rio Hondo Country Club	Adjacent
Suva Saint School	0.2
Sanitarium	0.2
Park	0.1
Percolation basin	Adjacent
St. Vincent's Seminary	0.1
Percolation basin	Adjacent
Rio Hondo Park	Adjacent
Park	Adjacent
Montebello Gardens School	0.3
Pio Pico School	0.2
Park	Adjacent
Flood control basin to Pomona	
Amusement park	0.2
Oilfield	0.2
Recreation area	Traversed
Flood control basin	Traversed
Recreation area	Traversed
Whittier Narrows Wildlife Sanctuary	Traversed
Flood control basin	Traversed
Equestrian area	Traversed

Table A2.1.12.6-1 (Continued)

FEATURE	Proximity to the Proposed Pipeline Route (Approx. Miles)
Whittier Narrows Wildlife Sanctuary	Traversed
Flood control basin	Traversed
Flood control basin	Adjacent
California Country Club	Adjacent
California Country Club	Adjacent
North Whittier School	0.3
Latin America Bible Institute	0.1
Valley Vocational Center	0.1
El Encanto Sanitarium	0.2
Fire station	0.2
Glenelder School	0.2
Hurley School	0.3
Rorimer School	0.2
School	0.3
Fire station	0.3
Walnut School	0.1
Diamond Bar Golf Course (Public)	Adjacent

Table A2.1.12.6-2

Special Features Within the Proposed Pipeline Corridor,

Pomona to Ehrenberg

FEATURE	Proximity to the Proposed Pipeline Route (Approx. Miles)
Pomona to Beaumont	
Industry corporate boundary	Traversed
Walnut corporate boundary	Adjacent
Vejar School	0.4
School	0.6
Suzanne School	0.9
Mt. San Antonio Junior College	1.0
Pomona corporate boundary	Traversed
Kellogg School	0.4
Ganesha High School	0.7
Kellogg Park	0.7
Marshall Junior High School	0.6
Arroyo School	0.9
Golf course	1.6
Los Angeles County Fairgrounds	2.1
Ganesha Park	1.8
Yorba School	2.8
Pomona Valley Hospital	2.6
St. Joseph School	0.9
Theodore Roosevelt School	1.4
Catholic girls' school	1.4
Lincoln Park	2.3
Emerson Junior High School	2.6
Garfield Park	2.6
Naval ordnance plant	Adjacent
Westmont Park	0.1
Westmont School	0.1

Table A2.1.12.6-2 (Continued)

FEATURE	Proximity to the Proposed Pipeline Route (Approx. Miles)
Hamilton School	0.6
Welch Park	0.4
Sacred Heart School	0.4
Golf course	0.1
Hospital	0.7
Elmwood School	1.6
Freemont Junior High School	0.4
Madison School	0.7
Washington School	1.8
Lexington School	0.1
Garey High School	0.3
Washington Park	1.6
Alcott School	1.3
Simons Junior High School	1.1
California State Polytechnic College	0.4
Puddingston Reservoir State Recreation Area	0.9
Golf course	0.9
Lorbeer Junior High School	1.1
Golden Springs School	1.1
Pomona corporate boundary	Traversed
Philadelphia School	0.6
Chino corporate boundary	Traversed
Newman School	1.4
Ramona Junior High School	1.6
Gird School	1.4
Villa Park	0.7
Chino Junior Fairgrounds	Adjacent
Parnell School	0.3

Table A2.1.12.6-2 (Continued)

FEATURE	Proximity to the Proposed Pipeline Route (Approx. Miles)
Mines	1.1
Boys Republic	0.1
California Institution for Men	Traversed
Los Serranos	0.9
Los Serranos School	1.8
Los Serranos Country Club	1.6
State fish hatchery	1.4
Clay pit	2.3
Gravel pit	2.6
Chino Downs	2.6
Chino corporate boundary	Traversed
Chino High School	1.7
El Rancho School	1.3
Ontario corporate boundary	1.7
Golf course	2.0
Chino Airport	0.1
Ontario corporate boundary	1.7
U.S. military reservation	Adjacent
Hawthorne Christian School	1.3
Fontana corporate boundary	Traversed
Jurupa Hills School	0.9
Kaiser Hospital	1.8
Rialto corporate boundary	2.0
Poplar School	1.8
Slover School	1.3
Gravel pit	1.8
Fontana Bird Park	0.3
Quarries	0.1
Quarry	1.3

Table A2.1.12.6-2 (Continued)

FEATURE	Proximity to the Proposed Pipeline Route (Approx. Miles)
Quarry	1.4
Boulder Hill Park	1.8
Quarries	1.3
Quarry	1.8
Jensen Quarry	1.3
Quarry	1.8
Glen Avon	2.0
Mission Bell School	2.0
Jurupa Cultural Center	2.0
Rubidoux	1.7
Quarry	1.4
Gravel pits	1.7
Avalon Park	2.0
Gravel pit	2.1
Crestmore	Traversed
Zimmerman School	0.4
Crestmore School	0.1
Quarry	0.1
Park	Adjacent
Quarry	0.6
Quarry	0.4
Borrow pit	0.7
El Ravino Country Club	0.3
Bloomington	1.5
Grimes School	1.7
Bloomington Junior High School	1.1
County museum	1.3
Bloomington High School	0.6
Children's Home	0.7

Table A2.1.12.6-2 (Continued)

FEATURE	Proximity to the Proposed Pipeline Route (Approx. Miles)
Rialto corporate boundary	0.1
Colton corporate boundary	Traversed
Colton Recreational Lake, Sam Snead Golf Course	1.4
High school	1.6
Lincoln School	1.3
Fleming Park	1.3
Colton Plunge Park	1.0
Washington School	1.1
Warm Creek Golf Course	0.9
San Salvadore School	0.6
Wilson School	0.7
Veterans' Park	0.4
Montecito Memorial Park	0.4
Loma Linda	Traversed
Tri-City Airport	0.6
Golf course	1.0
Grand Terrace	Adjacent
Terrace View School	0.7
Grand Terrace School	0.7
Terrace Hills School	1.3
Highgrove	1.8
Quarry	1.0
Gravel pit	Adjacent
Gravel pit	0.6
Quarry	1.0
Quarry	1.6
Riverside corporate boundary	1.8
San Bernardino corporate boundary	2.0

Table A2.1.12.6-2 (Continued)

FEATURE	Proximity to the Proposed Pipeline Route (Approx. Miles)
Golf course	2.3
Norton Air Force Base	2.0
Colton corporate boundary	Traversed
Loma Linda	Traversed
Victoria School	1.1
Union Academy	Adjacent
Hospital	0.1
Loma Linda University	Adjacent
Hospital	0.4
Redlands corporate boundary	Traversed
Lincoln School	2.0
Davis Park	1.8
Seventh Day Adventist school	1.4
Smiley Park	1.8
Sacred Heart School	2.0
McKinley School	1.6
Kingsbury School	1.7
Ford Park	2.1
Cope Junior High School	1.1
Smiley School	0.9
Community hospital	0.3
Kimberly School	1.3
Valley Preparatory School	1.7
Mission School	0.7
Bryn Mawr	Traversed
Redlands corporate boundary	Traversed
Redlands Country Club	1.6
Mariposa School	2.3
Golf course	0.4

Table A2.1.12.6-2 (Continued)

FEATURE	Proximity to the Proposed Pipeline Route (Approx. Miles)
Beaumont to Palm Springs	
Beaumont corporate boundary	Traversed
Stewart Park	0.7
High School	1.0
San Gorgonio Pass Memorial Hospital	0.7
Banning corporate boundary	Traversed
Sylvan Park	0.2
Hemmerling School	0.2
High school	0.1
St. Boniface School	0.3
Morongo Indian Reservation	Traversed
Gravel pit	0.4
Banning Airport	0.6
Morongo Indian Reservation	Traversed
Extractive use	1.4
Cabazon corporate boundary	0.6
Snow Creek	2.1
Bonnie Bell	2.3
Gravel pit	1.1
White Water	1.0
Palm Springs corporate boundary	0.4
Palm Springs to Indio	
North Palm Springs	1.1
Dos Palmas Corners	1.8
Palm Springs	1.7
Extractive use	0.7
Agua Caliente Indian Reservation	Traversed
Thousand Palms	0.3

Table A2.1.12.6-2 (Continued)

FEATURE	Proximity to the Proposed Pipeline Route (Approx. Miles)
Gravel pit	0.5
Thousand Palms Oasis	1.6
Gravel pit	0.2
Indio corporate boundary	0.5
Andrew Jackson School	1.0
Cabazon Indian Reservation	1.4
Gravel pit	2.2
<u>Indio to Hell</u>	
Cabazon Indian Reservation	1.4
Cactus City	0.1
Gravel pit	0.2
Gravel pit	1.4
Joshua Tree National Monument	1.4
Chiriaco Summit	0.4
Chiriaco Summit Airport	0.2
Joshua Tree National Monument	0.1
Gravel pit	1.4
Hayfield	2.1
Desert Center	0.3
Hell	0.6
Nicholls Warm Springs	2.8

APPENDIX A3.1.6

Methodology of Impact Analysis

APPENDIX A3.1.6

Methodology of Impact Analysis

Oxidant methodology

The evaluation of air quality impact is divided into three regions of the study area: (1) the Los Angeles Air Shed, (2) the areas along the pipeline route, and (3) the Midland terminal in Texas. Reflecting the severity of the baseline air quality problem and the availability of both ambient and emissions data, model studies have been performed to determine air quality for the Los Angeles and Midland regions. There are two air quality Environmental Research and Technology contract submittals, which are available upon request. The first, submitted in 1976, covers the Los Angeles Air Shed and includes a detailed discussion of methodology, computer models, validation, inventories, etc. The second (BLM, 1977) presents three subsequent studies: photochemical modeling of the Midland-Odessa area; estimated impacts onshore from tanker emissions in coastal waters (the "Moving Source" study); and estimated indirect air quality impacts resulting from abandonment and conversion of one natural gas pipeline.

In the Los Angeles Air Shed region, stability, wind speed, and wind direction have been quantified using meteorological data from the airports, and from regional wind stations. Trajectory analysis was employed to trace typical paths of pollutants from the facilities in question. Analysis of the meteorological conditions yielded the basin input data for advection and dispersion of pollutants used in the air quality models.

The photochemical oxidant impact was predicted through use of the ARTSIM computer model (successor to the DIFKIN, computer model developed for the U.S. Environmental Protection Agency) which computes the ground

concentrations of hydrocarbon, oxides of nitrogen, carbon monoxide, and photochemical oxidant along air trajectories computed from ground-station wind velocity data. Source oriented trajectories for critical conditions are established as the basis of operation of this model. Sufficient variation in trajectories is sought to identify significant geographic and temporal characteristics of present and projected pollutant concentration levels on the ground. Initial conditions and chemical reactivity assignments are chosen for the baseline calibration runs to provide a valid point of departure for the impact evaluation.

An existing Environmental Research and Technology, Inc. emissions model for the South Coast Air Basin (Nordsieck, 1974) is used to generate temporal and geographical distributions of HC and NOx emissions from stationary and mobile sources necessary as input to ARTSIM. This model incorporates functions which characterize the growth of different pollutant source types with time, and hence is capable of accounting for the cumulative effects of other new emissions sources which may accompany population or economic growth. For this analysis, the growth of area stationary source emissions has been based on population projections and economic growth indices as suggested by the California Air Resources Board (CARB, 1976). Increased vehicular traffic follows the projections contained in Nordsieck (1974), and the associated emission factors are calculated from EPA (1976). Adjustments also can be made in the inventory for the evaluation of mitigation measures.

The procedure for conducting an oxidant impact analysis with a trajectory model such as ARTSIM starts with selection of a one or more base days in a base year. The selection criteria for base days are availability of simultaneous air quality (morning HC and NOx) measurements near critical source sites, wind data sufficient to define air parcel trajectories traversing the sources, and ozone measurements near the afternoon locations of the trajectories, preferably on days which yielded elevated ozone levels. Accordingly, the base day selected for calibration of the ARTSIM model was 29 September 1969, a day for which the predecessor DIFKIN model had been

validated and which saw oxidant levels in excess of 30 pphm in many areas of the Los Angeles Air Shed. While a more recent episode day would have been more desirable, the time scale of this analysis could not accommodate the delays associated with acquisition of the necessary new data.

The aim of the trajectory analysis which accompanies this base day selection process is to identify trajectories which may carry pollutants from project related source sites to sensitive receptor areas or other populated areas. The trajectories simulated started at sunrise (0700 PDT) and traversed one of the areas of project related emissions at 0700, 0800, and 0900 PDT, respectively. Each set of three trajectories followed very similar paths eastward across the Air Shed. Hence, in the interest of speed and economy it was possible to select a single trajectory to represent the general location of the areas impacted by each project pollutant source. The middle cases (0800 PDT source traversal) were chosen to allow starting the air parcels at sunrise with initial conditions uninfluenced by project emissions and yet retain sufficient reaction time between source traversal and the anticipated early afternoon ozone peak. The paths followed by the selected impact evaluation trajectories are shown in Figure A3.1.6-1.

Geographical and temporal distributions of pollutant emissions prepared for the study are for the base year and for future study years with and without the project, and with and without the effects of mitigating measures. After selecting dispersion parameters appropriate to the observed base-day conditions of wind speed and mixing depth, calibration of the air quality model begins with refinements to these parameters to achieve a reasonable match between predicted and observed levels of carbon monoxide (CO). Initial pollutant concentrations in the air parcel are interpolated from data measured at monitoring stations near the starting location. Calibration of the photochemistry is then accomplished by adjusting hydrocarbon reactivities and initial conditions until the model reproduces measured peak ozone levels on the base day (without project related emissions).

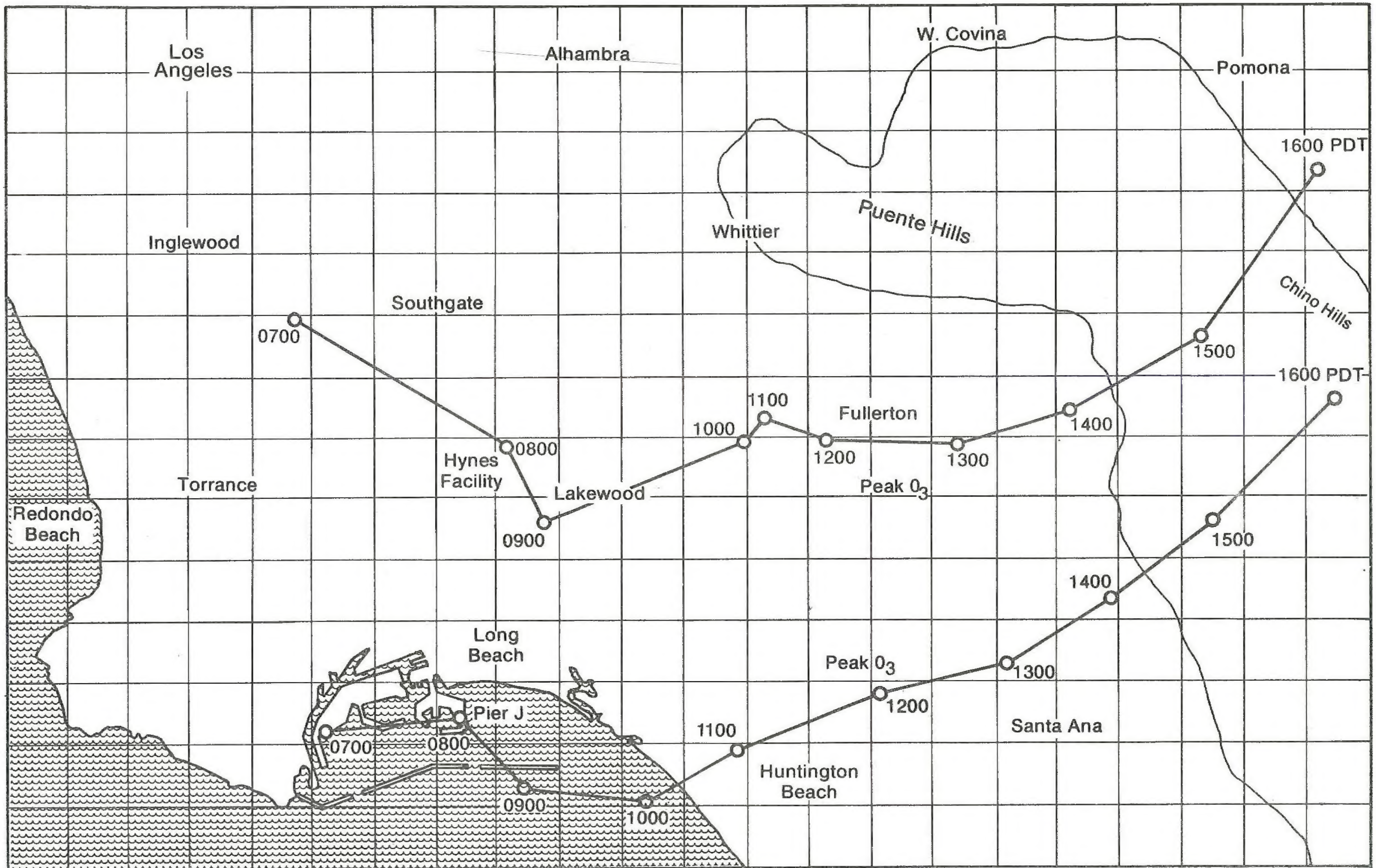


Figure A3.1.6-1 Selected trajectories for oxidant impact of terminal facilities

In the air quality impact analysis, the model is exercised using the same meteorological conditions, but with time variations of emissions appropriate for the desired scenarios. Initial pollutant concentrations for future year scenarios are reduced toward their global background levels in proportion to reductions in aggregated primary emissions. These final model runs yield the oxidant impacts of the proposed project with and without mitigation measures in the years 1980 and 2000 according to the input emissions scenario.

Sulfur dioxide methodology

SO_2 emissions expected to accompany the proposed project will result from operation of construction equipment and maintenance vehicles, off-loading of tankers, and refining the input crude oil component allocated to refineries in the Los Angeles Air Shed. The distribution of these emissions in the three study regions consisting of the Los Angeles Air Shed, the pipeline route and the Midland terminal in Texas is discussed in the following air quality impact sections. Analysis procedures included regional air quality model calculations for all SO_2 and particulates (TSP) sources in the Los Angeles Basin without the project and Gaussian model calculations of the short-term impacts from tankers discharging crude oil in the Port of Long Beach and from construction equipment.

Projected concentrations of SO_2 and TSP for the Los Angeles Air Shed without the project are discussed in Section 2.2.6.1. These calculations were performed using a proportional rollback model. This model related projected ambient pollutant concentrations to projections of emissions for 1980 and 2000 by assuming that changes in concentrations without background for the air shed are proportional to changes in emissions. Further discussion of this model is found below.

The impact of tanker emissions was calculated by assuming that the ships would emit SO_2 as elevated continuous point sources. These calculations

were made using a Gaussian Point Source Dispersion Model with worst case emissions and meteorological conditions. The impact from the emissions of construction equipment were made using a Finite Line Source Dispersion model situated near ground level. In modeling impacts in the Los Angeles Air Shed, calculations incorporated meteorological conditions for the Long Beach area on 1 March 1975; on that date, the air quality monitoring station at Long Beach recorded its highest sulfur dioxide level for the year. For the remainder of the project impact area, more severe generalized meteorology was assumed. Additional details are given below.

Total suspended particulate methodology

The sources of particulate include those resulting from fuel combustion by ships and construction equipment and resulting from fugitive dust emissions during the construction phase of the project. Fugitive particulate emissions consist of largely uncontrolled suspended particles made airborne by the mechanical action of wind or machinery. The most significant emissions are those related to sources causing fugitive particulate emissions. These construction-related emissions occur in all construction areas for pipe laying, terminal construction, and pump station construction.

The Gaussian dispersion models used to calculate SO_2 construction impacts were also used to calculate impacts from all other emission types, including airborn dust. Other emission species are nitrogen oxides, hydrocarbons, and carbon monoxide. Hydrocarbon emissions from storage tanks were modeled as arising from an elevated finite line source.

Proportional Rollback Model for SO_2 and TSP

Projected concentrations of SO_2 and TSP for the Los Angeles Air Shed without the project are discussed in Section 2.2.6.2. Concentrations presented were calculated using a proportional rollback model:

$$\frac{X'-B}{X-B} = \frac{Q'}{Q}$$

where--

X' = Projected ambient concentration,

X = Base ambient concentration,

Q' = Projected emissions,

Q = Base emissions, and

B = Ambient concentration.

The model specifies that changes in emissions are proportional to changes in concentrations when background concentrations are subtracted out (EPA, 1974). The model assumes spatially and temporally uniform emissions and dispersion rates and therefore provides gross estimates of concentration fields. This method was chosen for the analysis of SO_2 and TSP levels in the Los Angeles Air Shed because the project was expected to have little impact on the basin except in areas local to the pipeline and support facilities. The rollback model was applied on a county-by-county basis for Los Angeles, Riverside, San Bernardino, and Orange counties. Background concentrations were assumed to be zero for SO_2 and 27.5 $\mu g/m^3$ for TSP (AQMP Task Force, 1976).

Point source Gaussian dispersion model

To simulate resultant concentrations from the tankers, 10-minute maximum SO_2 concentrations were calculated using the expression for centerline values from a Gaussian plume (Turner, 1969):

$$\chi = \frac{Q}{\pi\ u\,\sigma_y\,\sigma_z}\ \exp\left\{-\frac{1}{2}\left(\frac{H}{\sigma_z}\right)^2\right\}$$

where--

χ = ambient concentrations (in $\mu g/m^3$),

Q = emission rate (in μg per second),

u = mean wind speed (in meters per second),

σ_y, σ_z = hoizontal and vertical dispersion, parameters (m),

H = effective stack height consisting of the sum of the physical stack height and buoyant plume rise (m) (Briggs, 1970), and

exp = the Napierian constant (e) raised to the given power.

One-hour averages were assumed to be 39 percent lower than the 10-minute averages given by this formula, as conservatively estimated by Turner. Three-hour average ground level concentrations were calculated using the following relationship:

$$\chi = \frac{2.03\quad Q}{u\ x\ \sigma_z}\qquad \exp\left\{-\frac{1}{2}\left(\frac{H}{\sigma_z}\right)^2\right\}$$

This expression assumes that plume dispersion at a downwind distance (x) can be represented by a 22.5-degree sector average to show the effects of wind variability and resultant plume meandering over the three-hour averaging period. Plume rise was calculated using formulations of Briggs (1970) and dispersion parameters for an elevated point emission source (ASME, 1968). Model results for 24-hour averaging periods assumed persistence of the high wind speed neutral meteorological conditions over 12 hours, with three 120,000 DWT tankers emitting SO_2 at a daily average rate determined by fuel use for pumping and hoteling (Table A3.1.6.1-4).

Modeling of construction-related emissions

All modeling was based on treating emissions as originating from a finite line source. This methodology was found to consistently result in realistic worst case estimates. Centerline ambient levels from the Gaussian plume are given by

$$\chi = \frac{2Q}{\sqrt{2\pi}\, U L \sigma_z} \exp\left\{-\frac{1}{2}\left(\frac{H}{\sigma_z}\right)^2\right\} \operatorname{erf}\left\{\frac{L}{\sqrt{8}\,\sigma_y}\right\}$$

where--

χ = ambient concentration (in $\mu g/m^3$) for a short averaging period (about ten minutes),

Q = the emission rate (in μg per second).

U = mean wind speed (in meters per second),

σ_y, σ_z = horizontal and vertical dispersion parameters (in meters),

L = length of the emission source (in meters),

H = effective plume height (in meters), and

erf = the error function.

This formula represents centerline ambient levels for near instantaneous averaging periods. Since winds are not constant, levels monotonically decrease with length of the averaging period. This decay rate depends on meteorological properties of the region and of the particular day. To obtain realistic worst case estimates, meteorological conditions, as recorded on 1 March 1975 at the Long Beach air quality monitoring station, were used. On that day, this station recorded the highest sulfur dioxide level for the year (0.064 ppm, Table 2.1.6.2-1). Dispersion of air pollutants was severely limited by a low mixing height and generally low wind speeds. Table A3.1.6-1 summarizes the meteorological data.

Table A3.1.6-1

Meteorological Data at Long Beach, 1 March 1975

HOUR	Wind Direction (Degrees)	Wind Speed (m/sec)	Stability Class[a]	Mixing Height (m)[a]
1	090	0.9	D	325
2	180	0.9	D	325
3	230	0.9	D	325
4	293	1.3	D	325
5	360	0.9	D	325
6	230	0.9	D	325
7	230	0.9	D	325
8	230	1.3	D	330
9	293	2.7	D	335
10	360	0.9	D	340
11	230	0.9	D	350
12	270	1.8	D	360
13	180	0.9	C	360
14	270	2.2	C	360
15	293	4.9	D	350
16	293	4.9	D	340
17	293	4.8	D	330
18	293	3.6	D	325
19	293	2.7	D	325
20	270	1.8	D	325
21	293	0.9	D	325
22	293	1.3	D	325
23	293	0.9	D	325
24	293	2.7	D	325

Source: SOHIO Transportation Company, 1977. Supporting Information for the SOHIO Permit Application.

[a] Los Angeles Airport data.

Emissions were assumed to occur uniformly during the hours 8 through 17, in Table A3.1.6.-1. These wind conditions are most representative of the area from Pier J through Walnut; beyond the Los Angeles Air Shed general worst case meteorology was assumed.

Maximum ambient levels were calculated for each direction (16) on the rose wind and for each averaging period. Centerline values were always assumed, so that the results are higher than expected. Other correction factors were employed to account for differences in construction parameters for the various construction sites, and to make the worst case analysis realistic:

1. A multiplicative factor was included to account for wind variability during each hour of averaging, namely, 1 - (0.06)(x/L), where x is the distance from the line source of length L; the smallest value allowed for this factor was 0.61.

2. For area sources, L was taken as equal to the width of the (square) emission area; distance was assumed to be measured from the front edge and a correction, x/(x+L), was made for the fact that emissions propagate from behind the front edge.

3. For pipeline construction up to Walnut, it was assumed that the maximum level for each averaging period would occur along a line perpendicular to the pipeline construction. For construction from Walnut to Beaumont, levels were multiplied by 0.85 to account for unfavorable wind angles for averaging periods of up to three hours. For longer periods the factor became 0.70 to also account for physical movement of the emission source (approximately 0.5 miles constructed in each 10 hour working day).

Beyond Beaumont conservative worst case general meteorology was assumed. The following corrections were made:

1. In place of the decrease of levels with length of averaging period based on Long Beach meteorology, the following decay was assumed, 0.76 for 3 hour averaging; 0.45 for 8 hours; 0.34 for 10 hours. From the latter figure 24-hour averaging becomes 0.14 (0.34 x 10/24). These factors include correction for movement of the emission source (about 1 mile each 10 working hours).

2. The 1-hour averaging correction formula (number 1, above) was also used for calculating ambient levels beyond Beaumont.

3. For pump station construction sites, the area correction factor (number 2, above) was used, as well as more conservative meteorological corrections: 0.96 for 3-hour averaging; 0.72 for 8-hour averaging; and 0.24 for 24-hour averaging.

4. Neutral stability and mean wind speeds of 1 meter per second (m/s) were assumed. In computing the ambient levels of hydrocarbons, a mean wind speed of 1.5 m/s was used; this is a more severe assumption than to assume a lower wind speed while accounting for more variable wind conditions in the 6 to 9 a.m. averaging period used for this Federal standard.

REFERENCES

Appendix 3.1.6

1. ASME. 1968. Recommended Guide for the Prediction of the Dispersion of Airborne Effluents. M. Smith, Ed. New York, New York.

2. Briggs, G.S. 1970. Some Recent Analyses of Plume Rise Observations. Second International Clean Air Congress of the International Union of Air Pollution Prevention Association. Washington, D.C.

3. Bureau of Land Management. 1976. Final Report, BLM-SOHIO Project, Volume 5:Air Quality. Prepared by Environmental Research and Technology.

4. California Air Resources Board. 1976. Emissions and Air Quality Assessment, Report No. ARB/EP-76001. Sacramento, CA.

5. Nordsieck, R.A. 1974. Air Quality Impacts of Electric Cars in Los Angeles, Appendix A: Pollutant Emissions Estimates and Projections for the South Coast Air Basin. Report RM-1905-A. General Research Corporation. Santa Barbara, California.

6. Turner, D.B. 1969. Workbook of Atmospheric Dispersion Estimates. U.S. Dept. HEW, Public Health Service, NAPCA, Cincinnati, Ohio.

7. U.S. Environmental Protection Agency. 1974. Guidelines for Air Quality Maintenance Planning and Analysis, Vol. 12: Applying Atmospheric Simulation Models to Air Quality Maintenance Areas. Publication EPA-450.

8. U.S. Environmental Protection Agency. 1976. Compilation of Air Pollution Emission Factors, Publication AP-42. Second Edition. Research Triangle Park, N.C.

APPENDIX A3.1.6.1

Emissions Calculations

APPENDIX A3.1.6.1

Emissions Calculations

Oil storage tanks-standing losses

There are two kinds of evaporative emissions associated with the operation of floating-roof storage tanks: standing storage losses and withdrawal losses. The empirical formulae developed by American Petroleum Institute (API, 1962) have been used to estimate these emissions. Standing storage losses can be calculated from:

$$S = K_t D_t \left(\frac{P}{14.7-P}\right)^{0.7} V_W^{0.7} K_s K_c K_p$$

where--

- S = standing storage evaporation loss, in barrels per year,
- K_t = a tank-type factor = 0.045 for welded tank,
- D_t = adjusted tank diameter, in feet (for tanks 150 ft or less in diameter use $D^{1.5}$; for tanks larger than 150 ft in diameter, use $D\sqrt{150}$),
- P = true vapor pressure of the stock at its average storage temperature, in pounds per square inch absolute,
- V_w = average wind speed, in miles per hour,
- K_s = a recommended seal factor = 1.0 for tight-fitting seals,
- K_c = a recommended factor distinguishing between gasoline and crude oil storage = 0.75 for crude oil, and
- K_p = a recommended paint factor for color of shell and roof = 0.95 for white color.

An equivalent form of the above formula (1), where S is expressed in pounds

per day per 1,000 gallons of tank capacity, is:

$$S = \frac{2.74\ WK_t}{V_c} D_t \left(\frac{P}{14.7 - P}\right)^{0.7} V_W^{\ 0.7} \quad K_s \ K_c \ K_p$$

where--

W = density of vapor = 4.419 lb/gal,

V_c = tank capacity, in barrels, and

all other symbols are defined previously.

The calculation of standing losses from one typical tank used in Long Beach, California, in Midland, Texas and at the pumping station near Indio is shown below.

Table A3.1.6.1-1

Calculation of Standing Loss from One Typical Tank[a]

LOCATION	Capacity of Tank (bbl)	Tank Diameter (ft)	Average Wind Speed (mph)	Standing Losses Per Tank (lb/d)
Long Beach	615,000	270	6	288.24
Midland	500,000	245	10	373.88
Indio	80,000	120	6	114.59

[a] Assumed true vapor pressure = 9.5 psia.

In the above calculations, it is assumed that all the storage tanks are similar in design and finish.

The proposed site at Pier J in Long Beach will have six storage tanks in operation; the proposed site at Dominguez Hills is expected to use two tanks. The site in Midland will have four tanks. The standing losses from these sites are computed and shown in Table A3.1.6.1-3.

Oil storage tanks-withdrawal losses

Withdrawal losses can be obtained by:

$$W = 448/D$$

where--

W = withdrawal loss, in bbl/million bbl throughput, and

D = tank diameter, in feet.

The withdrawal losses are computed for Long Beach and Midland and given in Table A3.1.6.1-2. The storage tank at the Indio pumping station is assumed to have no withdrawal loss.

Table A3.1.6.1-2

Calculation of Withdrawal Loss From One Typical Tank

DAILY THROUGHPUT (bbl/d)	Site	Number of Tanks	Withdrawal Loss (lb/d - tank)
0.7 million	Long Beach	8	26.96
0.5 million	Midland	4	42.42

The vapor density is taken to be equal to 185.6 lb/bbl. In the computations the level of throughput is divided in equal proportions among the number of tanks in use at each site. This is a worst case analysis; frequently the tanks would be floated on the line and most of the oil would bypass the tanks.

Oil storage tanks-total losses

The total emissions from each site depend on the number of tanks in operation and the level of daily throughput. The total emission is the sum of the standing losses and the withdrawal losses from the number of tanks in operation. The results are presented in Table A3.1.6.1-3.

Table A3.1.6.1-3

Total Emissions From Storage Tanks at Proposed Sites

DAILY THROUGHPUT (bbl/d)	Site	Number of Tanks	Total Standing Losses (lb/d)	Total Withdrawal Losses (lb/d)	Total HC Emissions (lb/d)
0.7 million	Pier J	6	1,729.44	161.76	1,891.20
	Dominguez Hills	2	576.48	53.92	630.40
0.5 million	Midland	4	1,495.52	169.68	1,665.20
	Pumping station	1	114.59	0	114.59

Ship stack emissions

Calculations of pollutant emissions from the ship's stack during various phases of tankship operations are based on the physical data in Table A3.1.6.1-4 as supplied by SOHIO, and emission factors found in Publication AP-42 (EPA, 1976) and repeated in Table A3.1.6.1-5 for convenience.

Assuming a residual oil density of 7 lb/gal, the pollutant emission rates shown in Table A3.1.6.1-6 may be calculated directly from the data in Tables A3.1.6.1-4 and -5. Emissions for pumping based on full power operating emission factors give maximum emission rates. The particulate emission rate for industrial boilers burning residual oil

is 23 lb/1,000 gal (EPA, 1976) which is closer to a cruise factor. In addition, 0.5 percent sulfur fuel oil will probably be a distillate oil with a particulate emission factor of only 15 lb/1,000 gal for industrial boilers or ships.

Table A3.1.6.1-4

Tankship Physical and Operational Data

PARAMETER	Applicable Data		
Nominal cargo size (DWT)	80,000	120,000	165,000
Overall length (ft)	811	869	899.5
Beam (ft)	125	136	173
Depth (ft)	57	71.7	75
Draft (ft)	43.6	54	55.3
Voyages/year (Valdez/Long Beach)	25	24.6	23.5
Estimated actual Cargo (tons)	78,300	116,200	164,500
Cargo pump capacity (tons/hr)	7,094	10,640	14,580
Fuel consumption at full power during cargo discharge (lb/hr)	7,093	12,040	14,373
Fuel consumption - hotel services only (lb/hr)	933	1,640	1,680
Fuel consumption at sea (tons/day)	125	154	138
Funnel height above water at loaded draft (ft)	105.6	120.25	117.25
Funnel diameter (ft)	2.92	5.17	3.25
Gas temperature at outlet (°F) in port	400	300	300
at sea	495		
Flue gas rate (CFM at exit temp.)[a]	46,600	70,600	82,500

Source: Williams Bros., 1976.

[a] Calculation based on fuel consumption. CFM: cubic feet per minute.

Table A3.1.6.1-5

Steamship Emission Factors (lb/1,000 gal)[a]

OPERATING CONDITIONS	Pollutant HC	NOx	SO_2	Particulate
Hoteling	3.2	36.4	159 x (%s)	10
Cruise	0.682	55.8	159 x (%s)	20
Full power	1.72	63.6	159 x (%s)	56.5

Source: Compilation of air pollutant emission factors, AP-42 (EPA, 1976).

[a] Assumption: Residual oil burned.

Table A3.1.6.1-6

Pollutant Emission Rates From Tankship

Operations in Long Beach Harbor

OPERATION	Nominal Ship Size (DWT)	HC (lb/hr)	NOx (lb/hr)	SO_2 (lb/hr)	Particulates[a] (lb/hr)
Hoteling	80,000	0.43	4.85	21.2 x (%s)	1.33
Hoteling	120,000	0.77	8.74	38.2 x (%s)	4.80
Hoteling	165,000	0.77	8.74	38.2 x (%s)	4.80
Full power	80,000	1.74	64.4	161 x (%s)	57.3
Full power	120,000	2.96	109.	273 x (%s)	97.2
Full power	165,000	3.53	130.	326 x (%s)	116.

[a] Reduce by a factor of 0.65 for burning distillate.

Crude oil vapor reactivity

The mass fraction of fugitive crude oil vapor which is sufficiently reactive to participate in the oxidant formation process was estimated using a vapor composition supplied by SOHIO, and a three-class reactivity classification scheme for organic compounds adopted by the

California Air Resources Board (CARB, 1976). In this scheme, Class 1 compounds are essentially nonreactive, Class 2 compounds yield moderate levels of ozone within the first day of solar irradiation, and Class 3 compounds give high yields of ozone within a few hours of irradiation. For the purposes of use in the ARTSIM simulation, Classes 2 and 3 are lumped together as a single reactive hydrocarbon species. Table A3.1.6.1-7 details the calculation of reactive fraction for the crude oil vapor emissions.

Table A3.1.6.1-7

Crude Oil Vapor Composition by Volume, Mass, and Reactivity

SPECIES	Mol %	Vol % HC	MW	Vol % x MW	Mass %
CO_2	3.90				
H_2O	5.30				
Methane (NR)[a]	9.90	10.9	16	1.74	
Ethane (NR)	12.60	13.9	30	4.17	
Propane (R)[b]	20.10	22.1	44	9.72	19.2
i-Butane (R)	8.60	9.5	58	5.51	10.9
n-Butane (R)	19.90	21.9	58	12.70	25.1
i-Pentane (R)	6.60	7.3	72	5.26	10.4
n-Pentane (R)	7.60	8.4	72	6.05	11.9
Hexane (plus as C_6)	5.50	6.1	90	5.49	10.8
	100.00	100.1		50.64	88.3

[a] Nonreactive.

[b] Reactive. Modeling was based on ignoring the methane and ethane fractions as nonreactive. The Environmental Protection Agency, however, considers the ethane fraction as reactive; they use the term "non-methane hydrocarbons".

Tankship fleet composition

The fleet of tankers which would deliver oil to the pipeline in Long Beach must have sufficient annual carrying capacity to maintain the average input necessary to keep the pipeline full. The required annual capaciy is 255.5 million bbl/yr. There are sufficient reasons to doubt that the SOHIO fleet tabulated in Table A3.1.6.1-8 (and in Chapter 1) can make sufficient trips each year to carry the required annual capacity. Factors include storms and other difficulties of passage between Port Valdez and the open ocean; the applicant has indicated concern in various studies (e.g. Long Beach Berth and Tankage Study, 1976) and in discussion of alternative fleet mixes. ERT, Inc., the contractor for the BLM, considers the annual calls (or round trips) per ship in the table to be the most reasonable estimate. On this basis, the annual cargo that the applicant proposed fleet could carry, 231 million barrels (see the table), would be 24.5 million barrels short of the proposed annual capacity.

Table A3.1.6.1-8

Basic SOHIO Tanker Fleet Capacity

DESCRIPTION (SOHIO)	Nominal (Thousand DWT)	Cargo Capacity (Thousand bbl)	Number Available	Annual Calls/ ship	Annual Cargo (Million bbl)	Total Calls/ year
Inerting and	165	1,192.6	4	23.5	112.10	94
Seg. ballast	120	842.5	3	24.6	62.18	73.8
Seg. ballast	80	567.7	4	25	56.77	100
Total					231.05	267.8

A worst case (or Case A) assumes that this amount would be carried on three 70,000 DWT non-segregated ballast tankers (Table A3.1.6.1-9). A best case (or Case B) fleet is given in Table A3.1.6.1-10. The worst case fleet would result in significant hydrocarbon emissions from

Table A3.1.6.1-9

Case A, 1980 Worst Case Fleet

TANKER TYPE	Nominal DWT (1000 tons)	Cargo Cap (1000 bbl)	No. Avail	Max. Calls/yr.	Max. Ann. Cargo (Million bbl)	Apportion. Cargo (Million bbl)	Apportion. Calls per year	Daily Probability of Call
SOHIO with Inerting and Seg. Ballast	165	1192.6	4	94	112.10	106.75	89.5	.245
	120	842.5	3	73.8	62.18	59.21	70.3	.193
SOHIO with Seg. Ballast	80	567.7	4	100	56.77	54.06	95.2	.261
Non-SOHIO, No Seg. Ballast	70	496.6	3	75	37.25	35.47	71.4	.196
TOTAL				342.8	268.30	255.49	326.4	.895

Table A3.1.6.1-10

Case B, 1980 Best Case Fleet

TANKER TYPE	Nominal DWT (1000 tons)	Cargo Cap (1000 bbl)	No. Avail	Max. Calls/yr.	Max. Ann. Cargo (Million bbl)	Apportion. Cargo (Million bbl)	Apportion. Calls per year	Daily Probability of Call
SOHIO with Inerting and Seg. Ballast	165	1192.6	4	94	112.10	97.68	81.9	.224
	120	842.5	3	73.8	62.18	54.18	64.3	.176
SOHIO with Seg. Ballast	80	567.7	4	100	56.77	49.47	87.1	.239
Non-SOHIO with Seg. Ballast	120	842.5	3	73.8	62.18	54.18	64.3	.176
TOTAL				341.6	293.23	255.51	297.6	.815

ballasting into cargo tanks (the so-called best case fleet would, however, result in higher sulfur dioxide emissions). Table A3.1.6.1-9 shows the allocation of cargo to the Case A fleet and the resulting daily probability of call of each ship type. Hence, for the Case A fleet, there would be at least one non-SOHIO, 70,000 DWT ship in Long Beach 71 days out of the year.

Relative frequency of tanker events

To obtain the probability for other events requires more extensive mathematical analysis. In the following calculations, assume each tanker is, on average, tied to a berth for 24 hours. Then the number of days each year two 70,000 DWT tankers would be tied up simultaneously would be approximately:

$$365 \times (71.4/365) \times (2/3 \times 71.4/365) = 9 \text{ days/year}$$

The factor 2/3 x 71.4 represents the apportioned calls per year of the two remaining ships available for simultaneous tie-up with the first ship.

To take into account the rarer event of simultaneous ballasting, the additional factor 2.2/24 is needed, where we assume ballasting requires 2.2 hours. Then, as an example, three 70,000 DWT tankers simultaneously ballasting would occur approximately:

$$24 \times 365 \times (2.2/24 \times 71.4/365) \times (2.2/24 \times 2/3 \times 71.4/365) \times (2.2/24 \times 1/3 \times 71.4/365) = 0.011 \text{ hours/year}$$

or approximately one hour every 89 years. This estimate can be found in Table 3.1.6.1.2-3. To obtain the frequency this event would occur in the 10 hour period from 10 p.m. to 8 a.m., the frequency above would be reduced by the additional factor 10/24.

Another calculation in Table 3.1.6.1.2-3 is the frequency three 165,000 DWT tankers would be simultaneously pumping out their cargo. Taking the apportioned calls (89.5) for these 4 tankers from Table A3.1.6.1-9 and the duration for pumping (164,500/14,580 = 11 hours) from Table A3.1.6.1-4, the calculation for approximate annual frequency becomes:

$$24 \times 365 \times (11/24 \times 89.5/365) \times (11/24 \times 3/4 \times 89.5/365)$$
$$\times (11/24 \times 2/4 \times 89.5/365) = 4.7 \text{ hours/year.}$$

The same expression, less the last parenthesis, represents the hours each year for two tankers simultaneously off-loading. The calculation gives 83 hours or 7.5 events each year. The applicant, however, claims this event would occur about once per year (Supporting Information for the SOHIO Permit Application, 1977).

It should be noted that the hypothetical fleets evaluated here were assumed to match the required cargo throughputs with little or no competition for loads, which serves to minimize the number of ships involved and maximize their utilization. Other fleets could certainly be selected which would increase or decrease the event probabilities, but any fleet design appears rather arbitrary at this time. It is also worth noting that in a strict sense, the type of probability analysis employed here only applies to completely random uncorrelated processes, whereas the operation of a group of ships plying a fixed route is actually neither random nor uncorrelated.

It is instructive to compare this simplistic methodology with the computer simulation performed by SOHIO (Long Beach Berth and Tankage Study, 1976). Various combinations of berths and surge-storage tanks at Pier J were studied. Tanker movements and storm events in Prince William Sound were simulated along with delays due to queuing in Long Beach. The purpose was to obtain the minimum terminal design that could compensate for tanker bunching due to storm activity in Alaska.

For the proposed terminal design (3 berths and 6 tanks at Pier J, the computer analysis found that on approximately 118 days no ships would be in harbor; on 140 days 1 ship would be in harbor; on 78 days 2 ships would be in harbor; on 24 days 3 ships would be in harbor; and on approximately 5 days 4 ships would be in harbor.

An analogous probabilistic calculation for number of ships at berth can be made. Let 365 x P represent the number of days exactly one tanker is at berth. Then, assuming randomness and the Case A fleet, P must satisfy the following equation for total apportioned calls per year:

$$326.4 = 365 \times (P + 2 \times [13/14 \times P^{2}] + 3 \times [12/14 \times 13/14 \times P^{3}]).$$

P then equals 0.12. And the estimate for one ship at berth is 150 days (vs. 140 from the SOHIO simulation). The left bracket times 365 gives the number of days with two ships at berth, namely 58 (vs. 78). Three at berth (365 times the right bracket) would occur 20 times each year assuming randomness (vs. 24 from the simulation). This calculation indicates that the terminal design would result in only a small degree of queuing relative to perfect randomness. It also indicates that randomness calculations only slightly understimate frequency of simultaneous events likely to occur at the proposed terminal.

Emissions from construction equipment

Emission factors for vehicular emissions used in this study are presented in Table A3.1.6.1-11 (EPA, 1976). Factors for hydrocarbons and oxides of nitrogen are presented to provide information on emissions of pollutants related to oxidant formation. Total emissions for construction and operational phases of the pipeline were calculated using estimated total fuel consumption for each phase of construction (Table A3.1.6.1-12) and fuel used annually at each maintenance base. Emission factors represent emissions for heavy duty gasoline and diesel

trucks (EPA, 1976). Although construction equipment emissions may vary from those assumed, the heavy duty truck emissions factors are generalized to provide a good approximation of emissions since exact information on vehicle types, mix, age, and use is not available. Individual contractors may use types and mixes of equipment differently; and heavy duty vehicle emissions factors may differ from those for construction equipment, depending on the equipment used, but these emission factors are considered representative.

Table A3.1.6.1-11

Emission Factors for Heavy-Duty Vehicles (lb/1,000 gal)[a]

POLLUTANT	Gasoline California	Gasoline Non-California	Diesel
Hydrocarbons	76	241	37
Oxides of nitrogen	52	170	370
Sulfur dioxide	5	5	27
Particulates	16	16	13

Source: EPA, 1976.

[a] These emission factors were obtained from multiplying conventional emission factors in (g/mi) by estimate for miles per gallon and converting to pounds per 1,000 gallons.

Table A3.1.6.1-12

Construction Estimates for Use in Emissions Calculations

SECTION[a]	Approximate Construction Time (days)	Distance per Day (ft/d)	Fuel Consumption Gasoline	Diesel
Pier J - Walnut	102	2,100	279,000	905,400
Walnut - Beaumont	119	2,500	240,600	593,500
Desert Center - Ehrensberg	38	5,500	79,400	210,200
Livingston - Eagletail Mt.	36	5,000	55,900	169,500
Jal - Midland	74	5,280	85,400	249,300
Pumping stations[b]	120		60,700	111,000
Midland terminal	304		106,400	312,800
Port and terminal	359		183,400	539,300
Conversion - Tie-In			1,520	3,060

Source: Williams Brothers Environmental Assessment, 1976.

[a] See Project Description.

[b] Per pump station.

The calculated emission rates of hydrocarbons and oxides of nitrogen from construction equipment are given in Table A3.1.6.1-13 for each pipeline segment and the pumping and terminal facilities.

Table A3.1.6.1-13

Average Emissions Resulting From Construction Equipment (lb/d)

SECTION[a]	HC	NOx	SO_2	Particulate
Pier J - Walnut	536	3426	253	158
Walnut - Beaumont	338	1950	145	97
Desert Center - Ehrensberg	363	2155	160	105
Livingston - Eagletail Mt.	548	2006	135	86
Jal - Midland	403	1443	97	62
Pumping station (per station):				
California	73	368	27	20
Non-California	156	428	27	20
Midland terminal	122	440	30	19
Port and terminal	94	582	43	28

[a] See Chapter 1.

Fugitive particulate emissions from construction

Fugitive particulate emissions resulting from construction activities were calculated for each phase of construction described in Chapter 1. Emission factors used in the calculations were derived separately for construction of pumping stations, terminal facilities, and the pipeline.

Emissions from terminal construction at Pier J and Midland and the 18 pipeline pump stations were calculated using an emissions factor of 1.2 tons per acre of construction per month of activity at each site with a 50 percent reduction of this factor due to dust control watering (EPA, 1976). This factor was derived from measurement of fugitive particulate from semi-arid sites with a medium activity level and a

soil silt content of 30 percent. It was assumed that the active area of construction at any time at each site was 20 percent for the port and terminal areas and 100 percent for the pump station sites. Duration of construction for the earth work phase is approximately eight months for the Pier J terminal, six months for the Midland terminal and five months for each pump station (Williams Brothers, 1976). Resultant emissions are given in Table A3.1.6.1-14.

Fugitive dust emissions for the construction of the pipeline segments were calculated using emission factors for agricultural tilling to represent surface grading along the pipeline route and aggregate storage load out factors to represent emissions from excavating and back filling operations. Emission factors used for calculations are (Cowherd, 1974):

Excavating	0.04 lb per ton of displaced soil
Back Filling	0.05 lb per ton of displaced soil
Grading	60 lb per disturbed acre

The amount of soil moved in trenching operations was determined based on a 6.5 foot by 5.5 foot trench and a soil density of 85 lb/ft^3 (Williams Brothers Environmental Services, 1976). The emissions due to grading were calculated for acreage included in the pipeline right of way with the pipe laying rates given in Table A3.1.6.1-12. Dust control waterings of pipeline construction are considered in the mitigation sections (Chapter 4) because of the difficulty obtaining water along the pipeline route. Resultant emissions for fugitive particulates for each pipeline segment are given in Table A3.1.6.1-15.

Fugitive dust emissions from maintenance activities are expected to be negligible and very scattered. The main source of fugitive particulates in the operational mode is expected to be limited to vehicular travel on unpaved service roads.

Table A3.1.6.1-14

Fugitive Dust Emissions for Terminal and Pump Station Construction

SITE	Total Area[a] (Acres)	Calculated Daily Emission (lb/d)
Pier J Terminal	42	340
Midland Terminal	50	400
Individual Pumping Station	5	200

[a] Data provided by Williams Brothers Engineering Co., Tulsa, Oklahoma.

Table A3.1.6.1-15

Fugitive Dust Emissions for Pipeline Segments

SECTION	Distance Per Day[a] (ft/d)	Calculated Emissions (lb/d)	(lb/ft)
Pier J-Walnut	2,100	420	0.20
Walnut-Beaumont	2,500	425	0.21
Desert Center-Ehrenberg	5,500	1,320	0.24
Livingston-Eagletail Mt.	5,000	1,100	0.22
Jal-Midland	5,280	1,373	0.26

[a] Data provided by Williams Brothers Engineering Co., Tulsa, Oklahoma.

Average emissions and emissions from other project sources

Sections in Chapter 3 on air quality impacts focused on sources of maximum peak emissions. There are other sources of lower level emissions. Total average emissions are of interest in determining the degree to which long-term project emissions would be exceeded by forthcoming emissions offsets (see Sections 2.1.6.5 and 4.1.5). There was insufficient time available to print the full tables of average total emissions, as given in the California Final Environmental Impact Report; copies are available upon request. These data are based on the emission factors that were agreed upon by the California Air Resources Board, the South Coast Air Quality Management District, and SOHIO. These emissions averages apply only to California, and are assumed to require trade-offs. Average hydrocarbon emissions at Midland, Texas, would result almost entirely from storage tanks (see Section 3.1.6.3.2). Other emissions at Midland would be negligible. Emissions at Midland are expected to require trade-offs. Average emissions from electrical generation to run pump stations in California and elsewhere are given in Sections 3.1.6.1.2 and 3.1.6.2.2.

There are emissions expected in constructing the marine terminal from sources other than those described in Chapter 3 and Appendix A3.1.6.1. These include emissions from dredges and from transporting rock for construction of the breakwater. Excluding emissions from construction equipment and vehicles, the daily emissions from marine construction total 1,036 pounds (lbs) of hydrocarbons (HC); 1,700 lbs of sulfur oxides (SOx); 2,248 lbs of particulates; 1,854 lbs of nitrogen oxides (NOx); and 1,518 lbs of carbon monoxide (CO). Lesser emissions result from employees' travel: 103 lbs of HC; 3.4 lbs of SOx; 10 lbs of particulates; 85 lbs of NOx; and 748 lbs of CO. The subtotal from marine construction is 1,310 lbs of HC; 1,756 lbs of SOx; 3,084 lbs of particulates; 2,734 lbs of NOx; and 4,646 lbs of CO. During pipeline construction, the principal source would be construction equipment and

vehicles. The only exception is HC emissions from employees' travel in southeastern California (607 lbs); otherwise, employees' travel and rail shipping are minor emissions sources. Daily emissions in California from construction equipment and vehicles total 1,124 lbs of HC; 554 lbs of SOx; 5,405 lbs of particulates; 7,836 lbs of NOx; and 11,919 lbs of CO. When employees' travel and rail shipping is included, the totals come to 2,052 lbs of HC; 687 lbs of SOx; 5,506 lbs of particulates; 8,771 lbs of NOx; and 18,368 lbs of CO.

Average emissions during operation of the pipeline in California would arise from electrical power for pumps; fugitive emissions from valves and pumps; and from maintenance. Average daily emissions from electrical consumption for operating pumps in the Los Angeles Air Shed come to 93 lbs of HC; 2,436 lbs of SOx; 233 lbs of particulates; and 1,164 lbs of NOx. Fugitive leakage would result in 14 lbs of HC daily. Maintenance on average comes to 8 lbs of HC; 1.4 lbs of SOx; 0.7 lbs of particulates; 27 lbs of NOx; and 135 lbs of CO. In southeastern California electrical comsumption by pumps would result in 33 lbs of HC; 860 lbs of SOx; 82 lbs of particulates; and 411 lbs of NOx. The fugitive leakage rate would be 10 lbs of HC. Emissions from maintenance are similar to those above and can be derived from the totals for operating the pipeline in California and which follow: 165 lbs of HC; 3,299 lbs of SOx; 316 lbs of particulates; 1,625 lbs of NOx; and 240 lbs of CO.

Daily emissions averages from port-related activity would result in the following levels: From storage tanks there would be 2,023 lbs of HC; from other fugitive sources 69 lbs of HC. From tanker fuel consumption there would be 44 lbs of HC; 1,135 lbs of SOx; 103 lbs of particulates; 597 lbs of NOx; and 8.4 lbs of CO; from tanker fueling 2 lbs of HC. From tugboats there would be 3.7 lbs of HC; 11 lbs of SOx; 7.2 lbs of particulates; 163 lbs of NOx; and 24 lbs of CO; from electrical generation in the terminal 48 lbs of HC; 1,247 lbs of SOx; 119 lbs of

particulates; and 596 lbs of NOx. Assuming that the tanker emissions which are released at sea and enter the Los Angeles Air Shed are represented on average by all emissions up to a point opposite Point Mugu, the daily average of emissions from tankers at sea would be 28 lbs of HC; 2,863 lbs of SOx (if the burn 2 percent sulfur content fuel); ; 171 lbs of particulates; 432 lbs of NOx; and 5 lbs of CO. The grand total of all daily emissions in California then becomes 2,383 lbs of HC; 8,555 lbs of SOx; 716 lbs of particulates; 3,420 lbs of NOx; and 325 lbs of CO.

This tabulation from the California Final Environmental Impact Report lacks one major indirect source of particulate and sulfur oxides emissions. The removal from service and conversion to crude oil transport of one natural gas pipeline would result in a reduced throughput of natural gas and force the additional consumption of more polluting fuels in California (see Sections 3.1.6 and 3.1.6.1.2 or, optionally, the new supplementary study on air quality impacts available from the BLM). This study by ERT estimates up to 5,807 lbs per day of additional sulfur oxides emissions released by gas-curtailed customers of Southern California Gas Company (SoCal) in the first year of abandonment. Additional particulate emissions are estimated at 1,542 lbs. These figures are based on an estimated gas curtailment to SoCal of 3.8 billion cubic feet (bcf) in the first year after abandonment, with the curtailment decreasing in the next few years (the capacity of the remaining natural gas transmission system would become less pressed). Total curtailment is currently estimated by the Federal Power Commission at 8.74 bcf during the first year, with 7.15 bcf the anticipated curtailment in California.

Emission estimates are subject to additional refinement. The emissions figures most likely to receive additional attention are those related to abandonment of the natural gas line, emissions from crude oil

storage tanks, and the proportion of emissions from tankers that would migrate into southern California.

Emissions from 200,000 barrels per day local consumption -- alternative scenarios

It is stated in Section 3.1.6.1.2 (under the heading Effect of Oil Replacement) that the applicant's trade-off credits attributable to development of Pier J would depend on assumptions of tanker mix with and without the presence of the marine terminal. In the following calculations it is assumed that the surplus itself and economic factors, rather than construction of the marine terminal, will basically determine the level of foreign crude oil that would be replaced by Alaskan oil in local consumption. This assumption is supported in the sections of this document which discuss energy supply and demand. Two tanker scenarios for delivering 200,000 bbl/d of Alaskan oil to San Pedro Bay without development of the marine terminal are discussed in this section. Hydrocarbon and sulfur dioxide emissions from tankers for these scenarios are compared to those from the all-SOHIO fleet (Table A3.1.6.1-8) using Pier J. The calculations are repeated for the mixed-SOHIO fleet in Table A3.1.6.1-9.

ARCO Scenario. It is assumed that three Atlantic Richfield Company (ARCO) 120,000 DWT tankers would carry the bulk of the Alaska oil that would replace the foreign oil currently entering San Pedro Bay; the oil would pass through ARCO's terminal. One 70,000 DWT tanker would carry the remainder over the new Macmillan Ring Free Motor Oil terminal or another existing terminal. ARCO would use its smaller tankers in Puget Sound; and SOHIO would carry the bulk of its Alaska oil to points outside of California.

To carry the 200,000 bbl/d, the ARCO tankers would each make 24 trips per year; the 70,000 DWT tanker would need to make 24.5 trips per year.

Using the emission factors (agreed upon by SOHIO, CARB, and the SCAQMD) 3.718 tons of SO_2 per trip by the 120,000 DWT tankers, 2.195 tons per trip of SO_2 and 1.05 tons per trip of hydrocarbons (HC) for the 70,000 DWT tankers, the result would be 329.14 tons of SO_2 and 25.73 tons of HC each year. In these calculations, emission factors for 70,000 DWT tankers were scaled down by the factor 7/8 from those given for 80,000 DWT tankers. The HC arises from ballasting in port the 70,000 DWT tanker to 15 percent of deadweight tonnage. It is assumed that the non-SOHIO tankers burn 2 percent sulfur content fuel oil in port.

<u>Panama Scenario</u>. It is assumed that all larger tankers (including ARCO's) are pressed into carrying Alaska oil to Panama or around Cape Horn. It is further assumed that SOHIO obtains local contracts that almost fully utilize their four 80,000 DWT tankers (22.5 trips per tanker per year to San Pedro Bay). The remainder of the 200,000 bbl/d would be carried on two 70,000 DWT tankers each making 22 annual trips.

The emission rate per trip for the SOHIO tankers is 0.627 tons of SO_2; segregated ballasting capacity is sufficient to result in no HC emissions. These assumptions result in 153.01 tons of SO_2 and 46.2 tons of HC annually.

<u>All-SOHIO Pier J fleet</u>. The proportioned annual trips to carry 200,000 bbl/d to Pier J by the SOHIO fleet in Table 3.1.6.1-8 are 7.44 trips by each of the four 165,000 DWT tankers, 7.79 trips by each of three 120,000 DWT tankers, and 7.91 trips by each of four 80,000 DWT tankers. The SO_2 emissions per trip are 0.952 tons from the 165,000 and 0.791 tons from the 120,000 DWT tankers. This results in 79.08 tons of SO_2 per year. There is sufficient segregated ballast to result in no HC emissions.

<u>Mixed-SOHIO fleet</u>. It was found by ERT, and is corroborated by the SOHIO tanker simulation study, that the all-SOHIO fleet would be unable

in practice to carry all of the 700,000 bbl/d proposed in Chapter 1. The fleet in Table A3.1.6.1-9 is a worst case for hydrocarbon emissions at the Pier J terminal. In carrying the 200,000 bbl/d of oil, the four 165,000 DWT tankers would each make 6.71 trips annually, the three 120,000 DWT tankers would each make 7.02 trips, the four 80,000 DWT tankers and the three 70,000 DWT tankers would each make 7.14 trips annually. This results in 107.13 tons per year of SO_2 and 22.49 tons per year of HC.

Trade-off credits. The ARCO scenario results in the larger SO_2 credits. The net reduction in SO_2 emissions, with respect to the all-SOHIO fleet, would be 242.4 tons per year (and 25.7 tons per year of HC). The Panama scenario results in a greater reduction of hydrocarbons, 46.2 tons per year (and 73.93 tons per year of SO_2). The mixed-SOHIO fleet would result in smaller net reduced emissions: 214.3 tons per year of SO_2 and 3.2 tons per year of HC for the ARCO fleet; and 45.9 tons per year of SO_2 tons per year of HC for the Panama fleet.

These calculations are only meant for illustration. The specific level of replacement of foreign crude and the potential fleet configurations are still indefinite.

REFERENCES

Appendix 3.1.6.1

1. American Petroleum Institute. 1962. Evaporation Loss from Floating-Roof Tanks. API Bulletin 2517. Washington, D.C.

2. California Air Resources Board. 1975. Report on Hydrocarbon Reactivity Study, Staff Memorandum 75-13-8.

3. Cowherd, C., J.H. Southerland, C.O. Massn. 1974. Development of Emission Factors for Fugitive Dust Sources. Paper Presented at the 67th Annual Meeting of the Air Pollution Control Association.

4. U.S. Environmental Protection Agency. 1976. Compilation of Air Pollution Emission Factors, Publication AP-42. Second Edition. Research Triangle Park, N.C.

5. Williams Brothers Engineering Co. 1976. Environmental Impact Assessment, West Coast-Mid-Continent Pipeline Project. Tulsa, Oklahoma.

APPENDIX A3.1.6.1.2

State of California

Air Resources Board,

Resolution 76-39,

October, 1976

APPENDIX A3.1.6.1.2

State of California

AIR RESOURCES BOARD

Resolution 76-39

October 8, 1976

WHEREAS, the federal Clean Air Act (par. 110) and Environmental Protection Agency regulations adopted pursuant thereto (40 CFR 51.12(b)) require that State Implementation Plans contain rules and regulations which prohibit the construction of a new emission source, or a modification to an existing source, where the same will interfere with or prevent the attainment or maintenance of a national air quality standard;

WHEREAS, Health and Safety Code pars. 40001 and 41507 require districts to adopt, as part of the State Implementation Plan required by par. 110 of the Clean Air Act, rules and regulations which endeavor to achieve and maintain the national standards, and authorize the Board to order revision of district rules and regulations where necessary to that end;

WHEREAS, Health and Safety Code par. 42301 requires that district permit systems prohibit the issuance of a permit for the construction, alteration, use or operation of any emission source where the same will prevent or interfere with the attainment or maintenance of any applicable air quality standard;

WHEREAS, the Board is empowered by the Health and Safety Code pars. 41500, 41502 and 41504 to review the rules and regulations of a district to determine whether they make reasonable provision to achieve and maintain state air quality standards and, after a public hearing, establish rules and regulations for a district which so provide if the district has not established such rules and regulations;

WHEREAS, the Board adopted on October 28, 1975 suggested new source review rules which meet the aforesaid state and federal mandates, and by letter dated November 26, 1975, requested the Southern California Air Pollution Control District to adopt the suggested new source review rules or equivalent rules;

WHEREAS, the Board finds that the Southern California Air Pollution Control District has not adopted new source review rules or regulations which adequately require the denial of a permit for the construction, alteration, use or operation of emission sources which will prevent or interfere with the attainment or maintenance of the state ambient air quality standards;

WHEREAS, the Board finds that without new source review rules substantially equivalent to those proposed for adoption by the staff of the Board, the rules and regulations of the Southern California Air Pollution Control District do not make reasonable provision to achieve and maintain the state ambient air quality standards;

WHEREAS, the Board finds that the Southern California Air Pollution Control District has failed to adopt new source review rules which meet the aforesaid federal requirements for State Implementation Plans; and

WHEREAS, the Board had conducted a public hearing and given notice thereof in accordance with all requirements of federal and state law;

NOW, THEREFORE, BE IT RESOLVED, that the Board amends the rules and regulations of the Southern California Air Pollution Control District by adopting therein Rules 213, 213.1 and 213.2, as amended;

BE IT FURTHER RESOLVED, that the aforesaid Rules 213, 213.1 and 213.2 as amended shall become effective immediately; and

BE IT FURTHER RESOLVED, that the aforesaid Rules 213, 213.1 and 213.2 as amended shall apply to any subject application for a permit filed with the District, but not finally ruled upon, prior to the aforesaid effective date.

BE IT FURTHER RESOLVED, that the staff of the Board, together with the staff of the District, monitor the implementation of said Rules, and report to the Board the effects on air quality, employment and business in the District by November 1, 1977.

BE IT FURTHER RESOLVED, that Rules 213, 213.1 and 213.2 as amended may not be amended except by the Board, or by the District provided that the Executive Officer finds that any amendment thereto made by the District does not impair the effectiveness or stringency of these rules.

Southern California Air Pollution Control District

New Source Review Rules

Rule 213. Standards for Permit to Construct: Air Quality Impact

Rule 213.1. Standards for Priority to Operate: Air Quality Impact

Rule 213.2. Definitions for Rules 213 and 213.1

Adopted October 8, 1976 by the Air Resources Board
to be effective immediately and to apply to any subject
application filed with the District, but not finally
acted upon prior to October 8, 1976

SOUTHERN CALIFORNIA AIR POLLUTION CONTROL DISTRICT

NEW SOURCE REVIEW RULES

RULE 213. Standards for Permits to Construct: Air Quality Impact

(a) General:

The Air Pollution Control Officer shall deny a permit to construct for any unit or units of a stationary source that fail to meet the applicable requirements of subsection (b) or (c) of this Rule.

(b) Best Available Control Technology:

1. New Stationary Sources:

The Air Pollution Control Officer shall deny a permit to construct for any unit or units constituting a new stationary source if such source will emit more than 15 pounds per hour of 150 pounds per day of nitrogen oxides, organic gases, or any contaminant for which there is a state or national ambient air quality standard (except carbon monoxide, for which the limits are 150 pounds per hour and 1500 pounds per day) unless the applicant shows that the new source is constructed using best available control technology.

2. Modifications to Existing Stationary Sources:

The Air Pollution Control Officer shall deny a permit to construct for any modification of any existing stationary source if such source after modification will emit more than 15 pounds per hour or more than 150 pounds per day of nitrogen oxides, organic gases, or any air contaminant for which there is a state or national ambient air quality standard (except carbon monoxide, for which the limits are 150 pounds per hour and 1500 pounds per day), unless the applicant demonstrates that the modification of the existing stationary source will be constructed using best available control technology, and:

A. That the modification would not result in a net increase in emissions of any pollutant affected by this Rule; or

B. That best available control technology is being, or is to be, applied to all existing units of the stationary source; or

C. That emissions from all of the existing units of the stationary source are controlled by use of technology that is at least as effective as that generally in use on similar stationary sources, and that the cost of installing best available control technology on existing units is economically prohibitive and substantially exceeds the cost per unit mass of controlling emissions of each pollutant through all other control measures; or

D. That the stationary source is a small business, as defined in subsection (1) of Section 1896 of Title 2 of the California Administrative Code; that emissions from all existing units of the stationary source are controlled through application of the best technology that is economically reasonable to apply to that stationary source; and that the cost of employing best available control technology is economically prohibitive.

(c) Air Quality Impact Analysis:

1. New Stationary Sources:

The Air Pollution Control Officer shall deny a permit to construct for any unit or units constituting a new stationary source if such source will emit more than 25 pounds per hour or 250 pounds per day of nitrogen oxides, organic gases, or any air contaminant for which there is a state or national ambient air quality standard (except carbon monoxide, for which the limits are 250 pounds per hour and 2500 pounds per day), or which is a precursor of any such air contaminant, unless he determines that the emissions from the new source will not cause a violation of, or will not interfere with the attainment or maintenance of, the state or national ambient air quality standard for that same contaminant (or, in the case of a precursor, for the contaminant to which the precursor contributes).

2. Modifications to Existing Stationary Sources:

The Air Pollution Control Officer shall deny a permit to construct for any modification of any existing stationary source if the modification will result in a net increase in emissions from the existing source of more than 25 pounds per hour or 250 pounds per day of nitrogen oxides, organic gases, or any air contaminant for which there is a state or national ambient air quality standard (except carbon monoxide, for which the limits are 250 pounds per hour and 2500 pounds per day), or which is a precursor of any such air contaminant, unless he determines that the emissions from the modified source will not cause a violation of, or will not interfere with the attainment or maintenance of, the state or national ambient air quality standard for that same contaminant, (or in the case of a precursor, for that contaminant to which the precursor contributes).

(d) Determination of Emission Increases:

In determining under subsection (b) 2.A. and subsection (c) 2. whether there has been a net increase in emissions and, if so, the amount of any such increase, the Air Pollution Control Officer shall consider all increasess and decrease of emissions caused by modifications to that stationary source pursuant to permits to construct issued during the preceding five years, or since the adoption of this Rule, whichever period is shorter. Emisson reductions required to comply with federal, state, or district laws, emission limitations, or rules or regulations shall not be considered to be decreases in emissions for the purposes of this subsection.

(e) Consideration of Future Emission Reductions:

In making the analysis required in subsection (h) 2., the Air Pollution Control Officer shall take into consideration the air quality impact of any reduction in the emissions of the same air contaminant which results from the elimination or modification of other existing stationary sources under the same ownership and operating within the same air basin. If reductions are to be based on planned elimination or modification of any stationary sources, the Air Pollution Control Officer shall condition the permit to operate to require such elimination or modification within not more than 90 days after the start-up of the new or modified source. Emission reductions required to comply with federal, state, or district laws, emission limitations, or rules or regulations shall not be considered to be decreases in emissions for the purposes of this subsection.

(f) Exemptions:

1. The Air Pollution Control Officer shall exempt from the provisions of subsection (c) of this Rule, any new stationary source or modification of any existing stationary source which:

   A. Will be in whole or in part a replacement for an existing stationary source at the same location if the resulting emissions of any air contaminant will not be increased. The Air Pollution Control Officer may allow a maximum of 90 days as a start-up period for simultaneous operation of the existing stationary source or replaced portions thereof, and the new stationary source or replacement; or

   B. Will cause demonstrable air quality benefits within the air basin; provided however, that the written concurrence of the California Air Resources Board and United States Environmental Protection Agency shall be obtained prior to the granting of an exemption hereunder; or

C. Will be used exclusively for providing essential public services such as schools, hospitals, or police and fire fighting facilities, but specifically excluding sources of electrical power generation other than for emergency standby use at essential public service facilities; or

D. Is exclusively a modification to convert from use of gaseous fuels to fuel oil because of demonstrable shortages of gaseous fuels, provided that all units constituting the modification will utilize best available control technology. Modifications for the purpose of this paragraph shall include the addition or modification of facilities for storing, transferring and/or transporting such fuel oil at the stationary sources. A condition shall be placed on the operating permit requiring conversion to gaseous or other equivalent low polluting fuels when they are, or become, available; or

E. Is air pollution control equipment which, when in operation, will reduce emissions from an existing source; or

F. Is portable sandblasting equipment used on a temporary basis within the air basin.

2. The Air Pollution Control Officer may exempt from the provisions of subsection (c) of this Rule, any new stationary source, or modification of an existing stationary source, which has been determined to be:

A. A new stationary source or modification of an existing stationary source utilizing unique and innovative control technology which will result in a significantly lower emission rate from the stationary source than would have occurred with the use of previously known best available control technology, and which will likely serve as a model for technology, to be applied to similar stationary sources within the State. In order for a stationary source to be exempted under this paragraph, the applicant must obtain the written concurrence of the California Air Resources

Board and the United States Environmental Protection Agency with the Air Pollution Control Officer's determination; or

B. A new stationary source or modification of an existing stationary source that represents a significant advance in the development of a technology that appears to offer extraordinary environmental or public health benefits or other benefits of overriding importance to the public health or welfare. In order for a stationary source to be exempted under this paragraph, the applicant must obtain the written concurrence of the California Air Resources Board and the United States Environmental Protection Agency with the Air Pollution Control Officer's determination.

(g) Notice Requirements for Proposed Exemptions:

Before granting an exemption under subsection (f) 1. B., (f) 2. A or (f) 2. B. of this Rule, the Air Pollution Control Officer shall publish a notice by prominent advertisement in at least one newspaper of general circulation in the District and shall notify in writing of his intention: the applicant, the United States Environmental Protection Agency, the California Air Resources Board and adjoining air pollution control districts. Calculations and technical data used by the Air Pollution Control Officer as the bases for granting exemptions pursuant to subsection (f) 1. B, (f) 2. A. or (f) 2. B. shall be made available to the California Air Resources Board and United States Environmental Protection Agency. Before granting an exemption under subsection (f) 1. B., (f) 2. A. or (f) 2. B. of this Rule, the Air Pollution Control Officer shall consider any comments received within 30 days after the date of publication or date of notification of the above agencies, whichever occurs later, and shall have obtained the concurrence of the California Air Resources Board and the United States Environmental Protection Agency.

In addition, the Air Pollution Control Officer shall notify in writing the United States Environmental Protection Agency and the California Air

Resources Board of the granting of an exemption under subsection (f) 1. A., (f) 1. C. or (f) 1.D.

(h) Procedures for Evaluation of Applications for Permits to Construct: Before granting a permit to construct for any unit of a new stationary source or modification subject to the requirements of subsection (c) of this Rule, the Air Pollution Control Officer shall:

1. Require the applicant to submit information sufficient to describe the nature and amounts of emissions, location, design, construction, and operation of the source, and to submit any additional information required by the Air Pollution Control Officer to make the analysis required by this Rule.

2. Analyze the effect of the operation of the new or modified stationary source on air quality in the vicinity of the new source or modified stationary source, within the air basin and within adjoining air basins. Such analysts shall consider the air contaminant emissions and air quality in the vicinity of the new source or modified source, within the air basin and within adjoining air basins at the time the new source or modification is proposed to commence normal operation. Such analysis shall be based on the application of existing state and local rules and regulations.

3. Upon completion of the evaluation, but before granting a permit to construct:

   A. Publish a notice by prominent advertisement in at least one newspaper of general circulation in the District, stating the preliminary decision to grant the permit to construct and where the public may inspect the information required by this subsection. A copy of the notice shall also be sent to the applicant, the United States Envrionmental Protection Agency, the California Air Resources Board and adjoining air pollution control districts. The notice shall provide a period of 30 days, beginning on the date of publication, or on the date of

notification of that above agencies, whichever occurs later, for the public to submit comments on the application.

B. Make available for public inspection at the Air Pollution Control District office, except as otherwise limited by law: the information submitted by the applicant, the air Pollution Control Officer's analysis of the effect of the source on air quality, and the preliminary decision to grant the permit to construct. Such Information shall also be forwarded to the California Air Resources Board for review.

C. Consider all comments submitted. If within the 30-day notice period the Air Pollution Control Officer receives a written request from either the United States Environmental Protection Agency or California Air Resources Board to defer the Air Pollution Control Officer's decision pending the requesting agency's review of the application, the Air Pollution Control Officer shall honor such request for a period of 60 days from the date of such request.

(i) Additional Applicant Requirements:

Receipt of a permit to construct shall not relieve the stationary source owner or operator of the responsibility to comply with other applicable portions of the District's Rules and Regulations.

(j) Severability:

If any portion of this Rule shall be found to be unenforceable, such finding shall have no effect on the enforceability of the remaining portions of the Rule, which shall continue to be in full force and effect.

RULE 213.1. Standards for Permits to Operate: Air Quality Impact

(a) Requirement for Permit to Construct as Condition for Permit to Operate: The Air Pollution Control Officer shall deny a permit to operate for any stationary source subject to the requirements of Rule 213 unless the applicant has obtained a permit to construct.

(b) Air Quality Impact Analysis for Sources Emitting Larger Quantities of Air Contaminants Than Assumed in the Analysis Performed Pursuant to Rule 213:

The Air Pollution Control Officer shall not grant a permit to operate to any stationary source that he determines emits quantities of air contaminants larger than were assumed in the analysis performed for the permit to construct for the source, unless the Air Pollution Control Officer performs the air quality impact analysis required by Rule 213 and determines that the actual emissions from the source will not cause a violation of, or will not interfere with the attainment or maintenance of, any state or national ambient air quality standard.

(c) Permit Conditions:

The Air Pollution Control Officer shall condition the issuance of a permit to operate, on such terms as are deemed necessary to ensure that the stationary source will be operated in the manner assumed in making the analysis required by Rule 213 or subsection (b) of this Rule, whichever is applicable. Where appropriate, such conditions shall prohibit a new stationary source which is a replacement for an existing stationary source from operating, unless the operation of the existing source is terminated. The Air Pollution Control Officer may allow a maximum of 90 days as a start-up period for simultaneous operation of the existing stationary source or replaced portion thereof, and the new stationary source or replacement portions thereof.

(d) Exemptions:

The Air Pollution Control Officer shall exempt from the provisions of this Rule, any stationary source which:

1. Has received a permit to construct prior to the adoption of Rule 213.
2. Is a continuing operation, without modification, of a stationary source that was previously exempt from the permit provisions of these Rules and Regulations and a permit to operate is required solely because of a change in permit exemptions stated in Rule 219.

(e) Severability:

If any portion of this Rule shall be found to be unenforceable, such finding shall have no effect on the enforceability of the remaining portions of the Rule, which shall continue to be in full force and effect.

RULE 213.2. Definitions for Rules 213 and 213.1

(a) STATIONARY SOURCE means a unit or an aggregation of units of non-vehicular air-contaminant-emitting equipment which is located on one property or on contiguous properties; which is under the same ownership or entitlement to use and operate; and, in the case of an aggregation of units, those units which are related to one another. Units shall be deemed related to one another if the operation of one is dependent upon, or affects the operation of, the other; if their operation involves a common or similar raw material, product, or function; or if they have the same first three digits in their standard industrial classification codes as determined from the Standard Industrial Classification Manual published in 1972 by the Executive Office of the President, Office of Management and Budget.

In addition, in cases where all or part of a stationary source is a facility used to load cargo onto or unload cargo from cargo carriers, other than motor vehicles, the Air Pollution Control Officer shall consider such carriers to be parts of the stationary source. Accordingly, all emissions from such carriers (excluding motor vehicles) which will result in an adverse impact on air quality in the State of California shall be considered as emissions from such stationary source. Emissions from such carriers shall include those that result from the operation of the carriers' engines; the purging or other method of venting of vapors; and from the loading, unloading, storage, processing, and transfer of cargo.

(b) MODIFICATION means any physical change in, or any change in the method of operation of, a stationary source.

For the purposes of this definition:

1. Routine maintenance or repair shall not be considered to be physical changes, and
2. An increase in production rate or operating hours shall not be considered to be a change in the method of operation, provided that these increases are not contrary to any existing permit to operate conditions.

(c) BEST AVAILABLE CONTROL TECHNOLOGY means the maximum degree of emission control for any air contaminant emitting equipment, taking into account technology which is known but not necessarily in use, provided that the Air Pollution Control Officer shall not interpret best available control technology to include a requirement which will result in the closing and elimination of or inability to construct a lawful business which could be operated with the application of the best control technology currently in use.

(d) Severability:

If any portion of this Rule shall be found to be unenforceable, such finding shall have no effect on the enforceability of the remaining portions of the Rule, which shall continue to be in full force and effect.

APPENDIX A3.1.11

Propagation Model and Source Levels

APPENDIX A3.1.11

Propagation Model and Source Levels

Sound propagation methodology

Various models have been formulated to predict propagation of sound energy. The prediction of noise levels at receptor points in the vicinity of construction requires consideration of three factors:

1. Identification and location of construction equipment and operations which are significant noise sources.
2. Distances between construction equipment and noise receptor points.
3. Intervening obstacles or barriers.

To estimate noise levels, the Environmental Research and Technology (ERT) noise propagation model, ERTNOI, was employed. This is a field propagation model which computes the sound pressure level at a specified receptor site due to sources characterized by A-weighted noise levels at reference distances. The model includes propagation factors such as barrier effects of building structures and earth berms, steady winds, detailed atmospheric absorption and source directivity. The computer inputs and outputs are summarized in Table A3.1.11-1.

Table A3.1.11-1

Computer Inputs and Outputs - ERTNOI[a]

ERTNOI INPUTS	ERTNOI Outputs
Number of sources	Sound pressure level by octave band and overall A-weighted level due to individual sources and total of all sources at each receptor
Cartesian coordinates of each source	
Octave band sound power level of each source	
Directivity factor (in 22.5 degree increments, for each source)	
Number of receptors	
Cartesian coordinates of each receptor	
Cartesian coordinates for end points of each barrier[b]	
Height of each barrier[b]	
Wind direction angle and speed[b]	
Air absorption vs. frequency table[b]	

Source: Environmental Research and Technology, Inc., unpublished document, 1976.

[a] Designed by Environmental Research and Technology, Inc., Noise Propagation Model.

[b] Optional.

Summation of levels

Noise levels in decibel units are not linearly additive since the decibel is a logarithmic unit. When noise from more than one source is being generated simultaneously, the correct dBA value can be obtained by using the following summation chart (Table A3.1.11-2):

Table A3.1.11-2

dBA Summation Chart for Two Sources

WHEN TWO DECIBEL VALUES DIFFER BY	Add the following Amount to the Higher Value
0 or 1 dBA	3 dBA
2 or 3 dBA	2 dBA
4 or 9 dBA	1 dBA
10 or more dBA	0 dBA

Source: DEIR, Port of Long Beach, 1976.

Use of resultant noise level

By adding the propagated noise level to the ambient noise level through the above chart, the estimated resultant level is obtained. A comparison of the resultant level with the ambient level is used in impact assessment. See Section 3.1.11 for general impact categories.

Sources

Table 3.1.11-3 lists equipment which is typically required in the construction of oil pipeline and terminal facilities, and which are significant from a noise analysis standpoint. Also included in this list are the corresponding A-weighted noise emission characteristics of the equipment.

Table A3.1.11-3

Noise Emission Characteristics of Pipeline and Pump Station Construction Equipment

EQUIPMENT	Typical Range[a]	Analysis Value[b]
Jack hammer	88-98	88
Dozer	82-95	80
Backfiller	82-95	80
Truck w/lowboy	82-92	80
Backhoe	80-92	80
Sideboom	78-92	80
Air compressor	85-91	81
Ditching machine	80-90	85
Dragline 1-1/4 yard	80-90	85
Motor crane	78-87	80
Flatbed truck	84-87	85
Pickup	70-85	70
Welding rigs	72-82	75

[a] Data are modified from U.S. Environmental Protection Agency NTID 300.1, 1972, p.2-108. (Levels are in dBA at 50-foot reference distance.) These values are based on a range of equipment and operating conditions.

[b] Analysis values are intended to reflect noise levels from equipment in good condition, with well-fitted mufflers, air intake silencers, etc. In addition, these values assume some averaging of sound level over all directions from the listed piece of equipment.

REFERENCES

Appendix 3.1.11

1. Environmental Research and Technology. 1976. SOHIO Crude Oil Transportation System Tanker Traffic Study. Unpublished. Prepared for Bureau of Land Management.

2. Port of Long Beach, Calif. Public Utilities Commision. 1976. Draft Environmental Impact Report, Vol. 1.

APPENDIX A3.1.11.1.1

Worst Case Construction Scenario, Dominguez Hills Terminal

APPENDIX A3.1.11.1.1

Worst Case Construction Scenario, Dominguez Hills Terminal

Construction of the terminal is expected to take approximately 8 to 12 months. During this time the types, numbers and locations of construction equipment will vary, depending on the particular phase of construction.

To evaluate the magnitude of terminal construction noise levels, an adverse case scenario was postulated. This scenario consists of two bulldozers, one back hoe, one diesel crane, one welding generator, and one front-end loader simultaneously in operation at one point.

To compute the resulting noise levels associated with these sources, a noise propagation model (ERTNOI) was used (Appendix 3.1.11). In this application, the following conservative (maximum noise) assumptions were used:

1. Omnidirectional sources.
2. No wind.
3. No barriers.
4. All equipment operating at peak levels simultaneously.

The variation of noise level with distance for this scenario is shown in Figure A3.1.11.1.1-1.

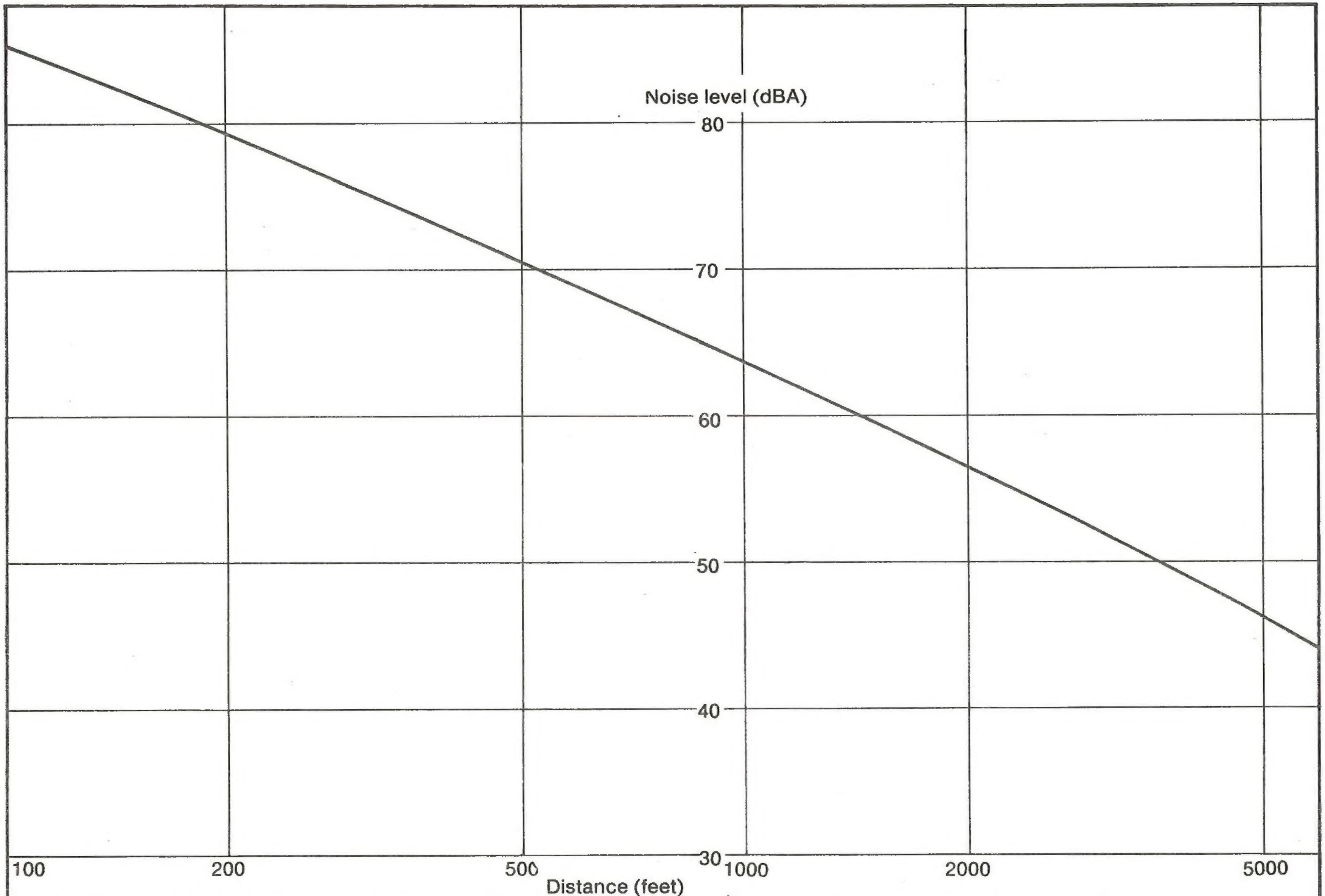


Figure A3.1.11.1.1-1 Predicted noise level versus distance from terminal construction site

APPENDIX A3.1.11.1.2

Assessment of Noise From Pump Stations

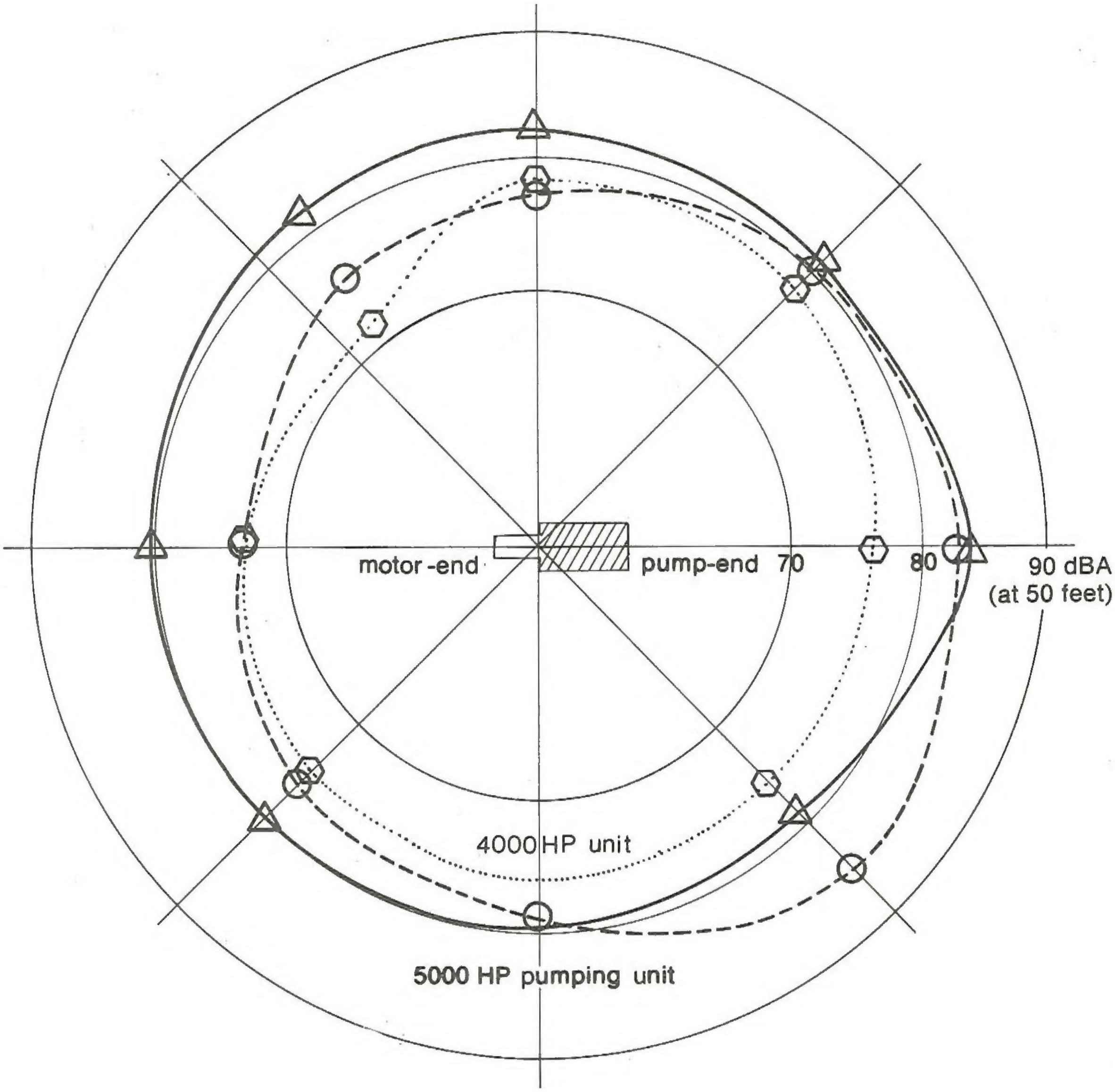
Assessment of Noise From Pump Stations

Pump station field measurements

Noise emission characteristics of representative electric-motor pump units were determined by field measurements (Williams Brothers Waste Control, Inc., 1976) and are summarized in Appendix Figures A3.1.11.1.2-1 and -2. Measurement data suggested that A-weignted noise emission is a function of suction (inlet) pressure, rated horsepower, and direction from the unit. However, insufficient pump station design and measurement data was available to adequately describe the suction pressure and horsepower influence on pumping unit noise emission. For this reason, the 5,000-hp unit pump end data is used to obtain an upper limit to represent the pumping unit noise source.

Transformers

Transformer specifications are not available at this stage of project planning. However, it is possible to make some general observations regarding the transformer as a noise source. In general, there are two components of transformer noise: (1) noise originating from core vibration (from magnetostrictive elongation and contraction) and (2) fan noise from the transformer's cooling system. The first of these components is distinctly tonal in character with amplitude peaks at twice the 60-Hertz alternating current (ac) line frequency and the even harmonics thereof (120 Hertz, 240 Hertz, etc.). The fan noise is generally broad-band noise and of less importance than the core noise (Teplitzky, 1974, 1976). Under conditions of low-level broad-band noise, the tonal aspect of transformer



Source: Williams Brothers Sanitation Co.

Figure A3.1.11.1.2-1 Sound-level directivity patterns of main-line pumping units

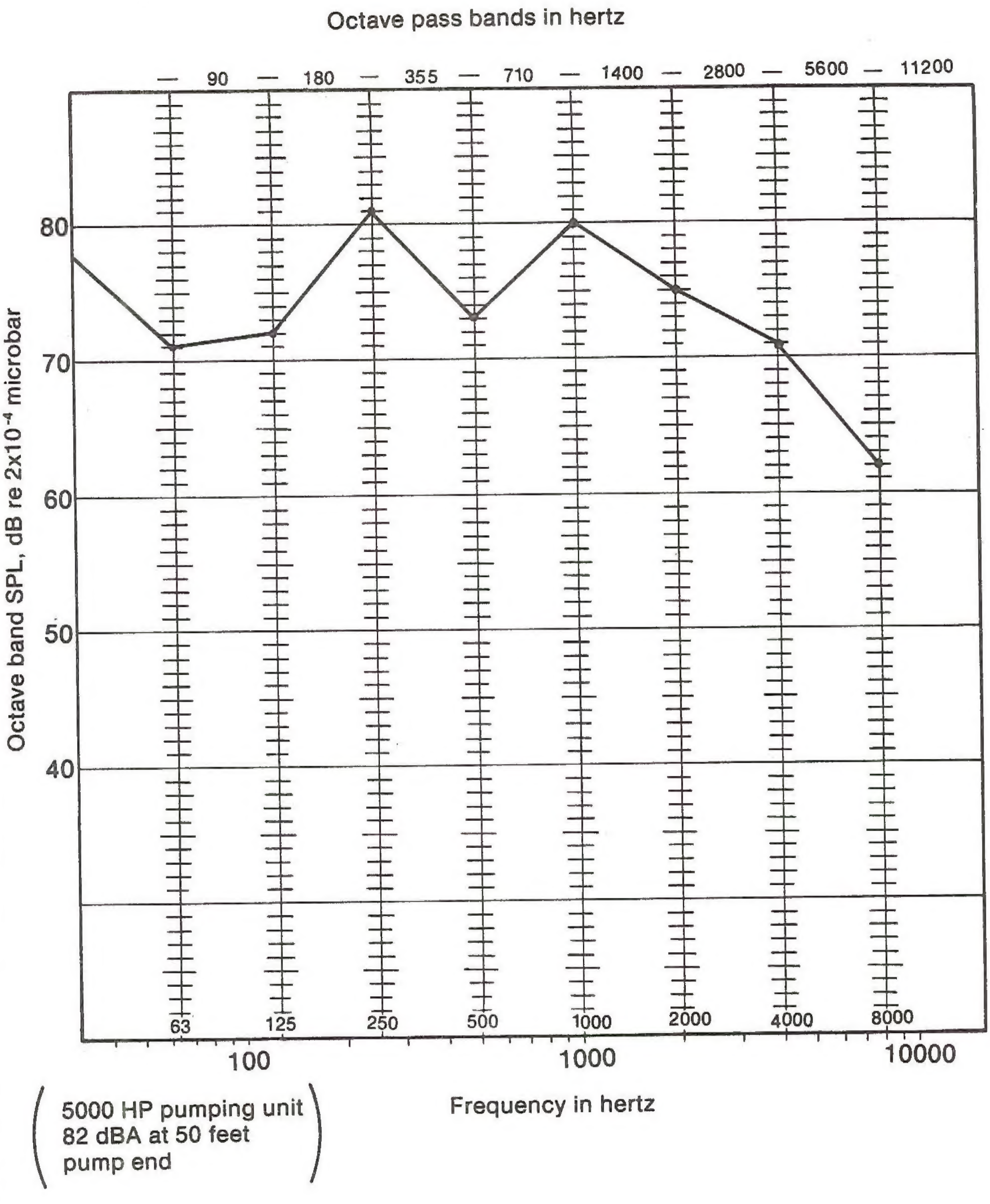


Figure A3.1.11.1.2-2 Main-line pumping unit octave band noise levels

noise has, in a number of instances, resulted in community noise complaints, (Hoover, 1976). However, for the pump station, the masking effect of noise from the main line pumps suggests that there is little chance that transformer noise will ever be audible in the community.

Worst case noise assessment model

Actual noise levels will depend on specific site factors. An upper limit calculation was performed using ERTNOI under the following assumptions: three 5,000-hp units operating simultaneously, a direction angle of maximum noise emission (approximately in line with the axis of pump end), no barriers, and no wind. Noise levels at various distances are given in Figure A3.1.11.1.2-3.

Noise levels due to the operation of main line pump stations are principally a function of source characteristics (number and horsepower of pumping units), the existence of intervening barriers, and receptor distance from the pump station. No barriers were assumed in the computer run. If barriers are to be included, or if fewer pumps are to be installed, calculated noise levels are lower, by the following increments:

Factor	Subtract
a 2-pump station	1.8 dBA
a 1-pump station	4.8 dBA
Barrier blocking the line-of-sight	5 to 10 dBA

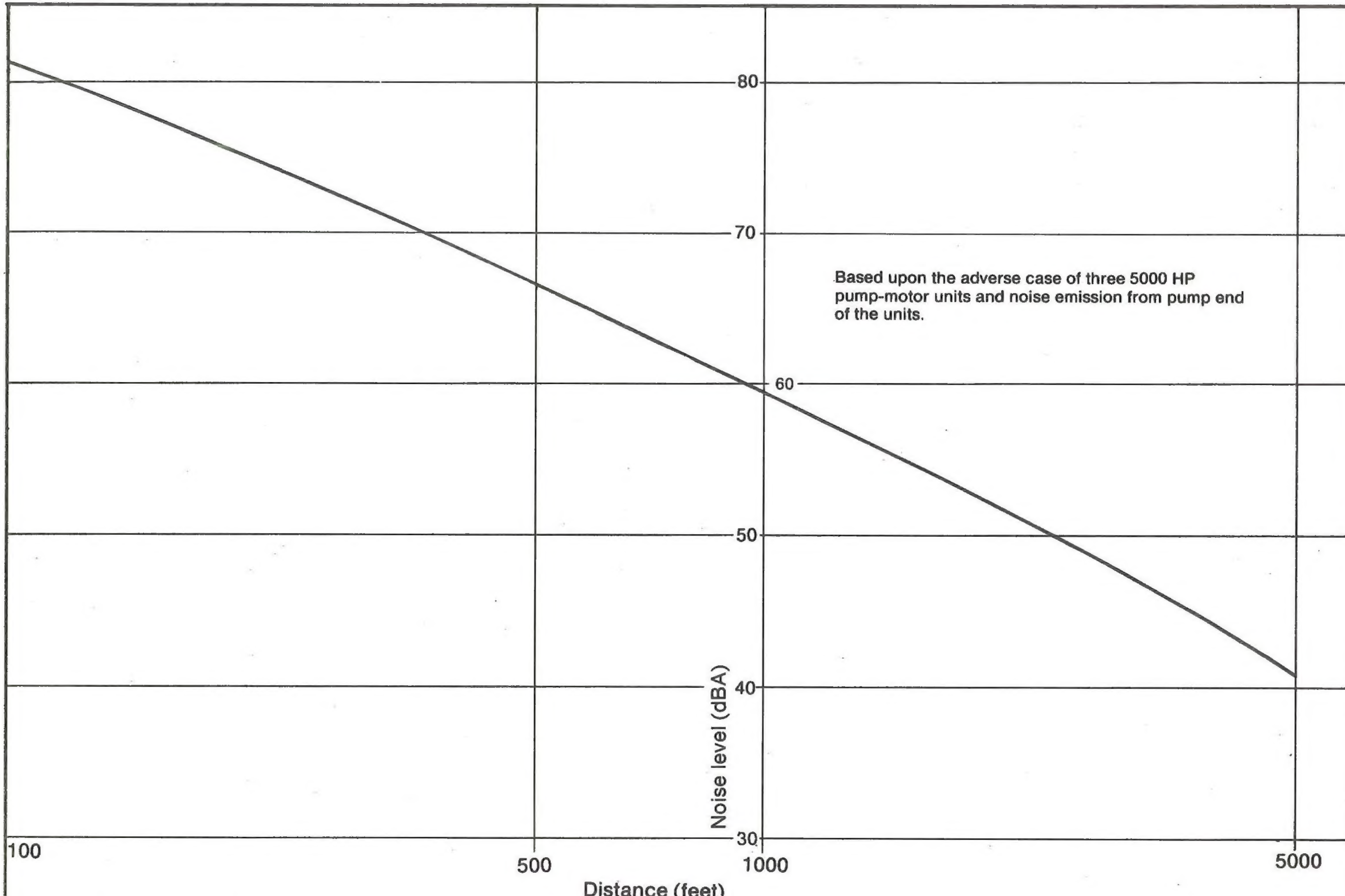


Figure A3.1.11.1.2-3 Predicted noise level versus distance from operating main-line pump station

REFERENCES

Appendix 3.1.11.1.2

1. Hoover, R.M. 1976. Study of Community Noise Complaints Caused by Electric Power Plant Operation. Noise Control Engineering.

2. Tephitzby, A.M. 1974. Electric Utility Noise in the Community, Inter-noise 74.

3. Williams Brothers Waste Control, Inc. 1976. Noise Survey of Pipeline Pump Stations, Report WBWC 2276-200. Prepared for Williams Brothers Engineering Company SOHIO project, Tulsa, Oklahoma.

APPENDIX A3.1.11.2.1

Noise Levels from Pipeline Construction

APPENDIX A3.1.11.2.1

Noise Levels from Pipeline Construction

Figure 1.2.3.2-1 and the accompanying text in Chapter 1 describe the pipeline construction spread. In the flat undeveloped areas, pipeline construction is expected to proceed at a rate of up to 1 mile per day. In the Pier J to Walnut section, where level of urbanization is high, new space will be confined and the average completion rate may be on the order of 300 feet per day. Use of equipment will vary. Noise level data for pipeline equipment is tabluated in Appendix Table A3.1.11-3. See Appendix A3.1.11 for methodology in predicting noise levels.

To evaluate the magnitude and variation with time of noise levels produced by pipeline construction, two scenarios are postulated: an "urban" one representing a clumped construction profile, and a "suburban" one representing an extended construction area. The significant elements of the construction spread scenarios are summarized in Figure A3.1.11.2.1-1.

The noise level contours corresponding to "urban" and "suburban" pipeline construction scenarios are shown in Figures A3.1.11.2.1-2 and -3. The contours representing the lower noise levels are approximately circular for both scenarios and have similar included areas. At distances closer to the sources, the higher noise level contours approximate the shape of the spread.

Noise from pipeline construction, at any specified receptor point, is of relatively short duration. Figure A3.1.11.2.1-4 illustrates the calculated duration in days that any given noise level will be exceeded for noise receptors located at distances of 200, 500, and 1,500 feet from the center of construction. This figure shows noise levels of 60 dBA will be exceeded

Construction spread scenarios[a]

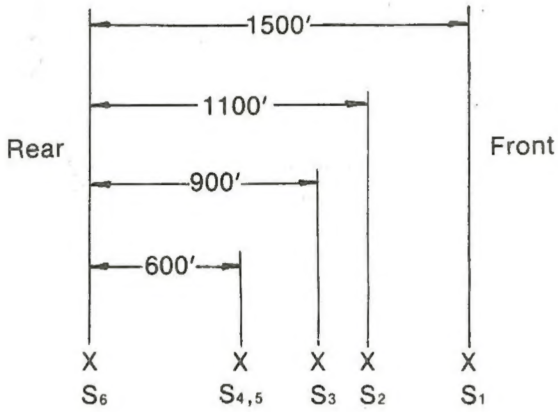
Urban case:
(All equipment treated as one point source)

X

S_1 to S_6

Sources S_1 through S_6 at a single point.

Suburban case: (1500 feet construction spread)



Sources S_1 through S_6 in a line, separated as indicated.

Construction operation	*Symbol*	*Equipment*	*Noise Level*[b] *(dBA)*
Trenching, clearing, grading	S_1	Backhoe, 1¼ yd. diesel	85
Pipe stringing, bending, lineup	S_2	Motor crane, diesel	80
Welding	S_3	Engine powered generator	75
Lowering in	S_4	Sideboom 572 diesel	80
Lowering in	S_5	Sideboom 572 diesel	80
Backfilling	S_6	Front end loader	85

[a]Based on a description of pipeline construction procedures, (University of Texas, 1976). Also described in Chapter 1.

[b]At a reference distance of 50 feet. These values are based upon well maintained equipment with tight fitting mufflers, intake silencers and other standard noise mitigating features.

Figure A3.1.11.2.1-1 Construction spread scenarios

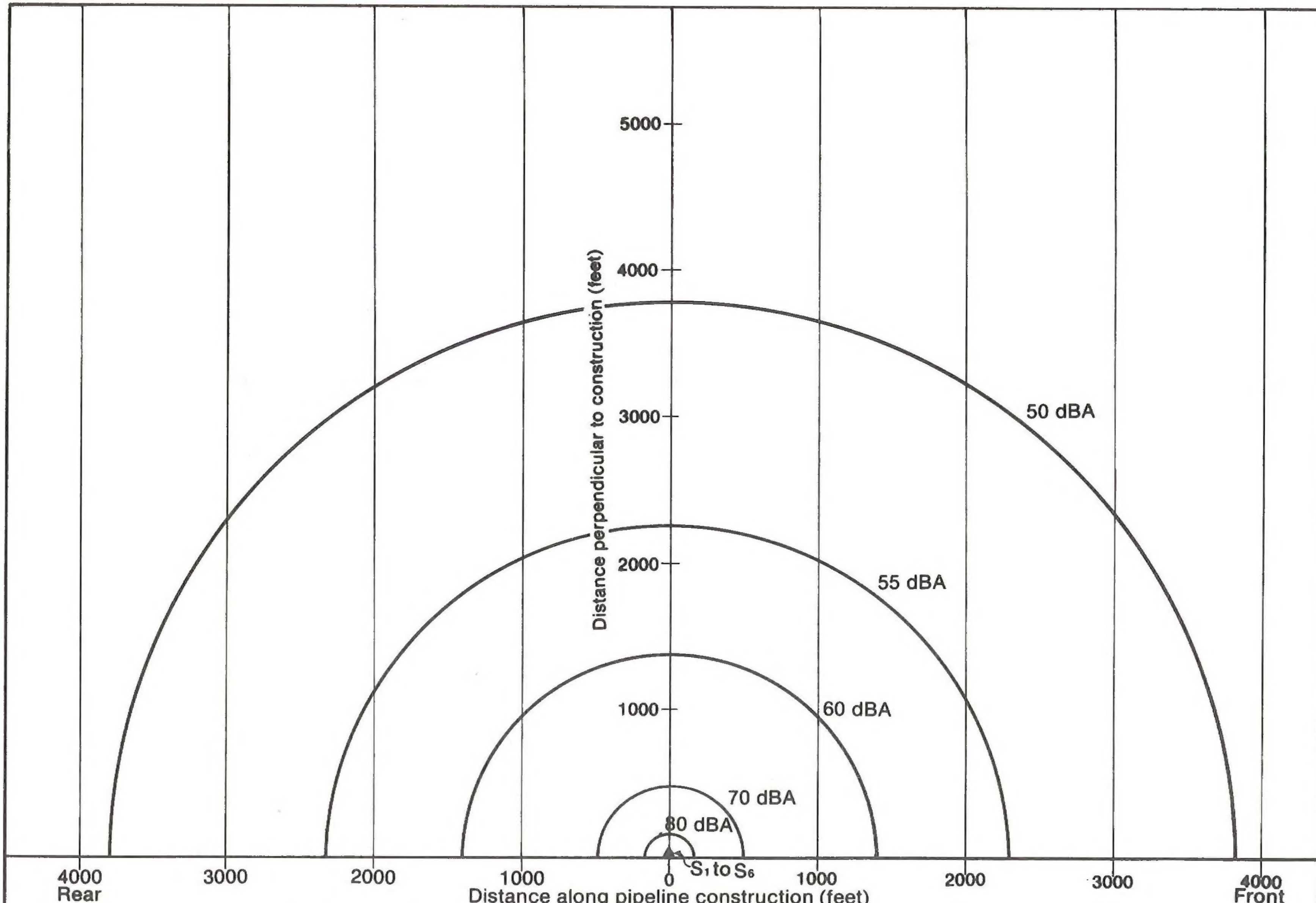


Figure A3.1.11.2.1-2 Noise levels from urban pipeline construction scenario

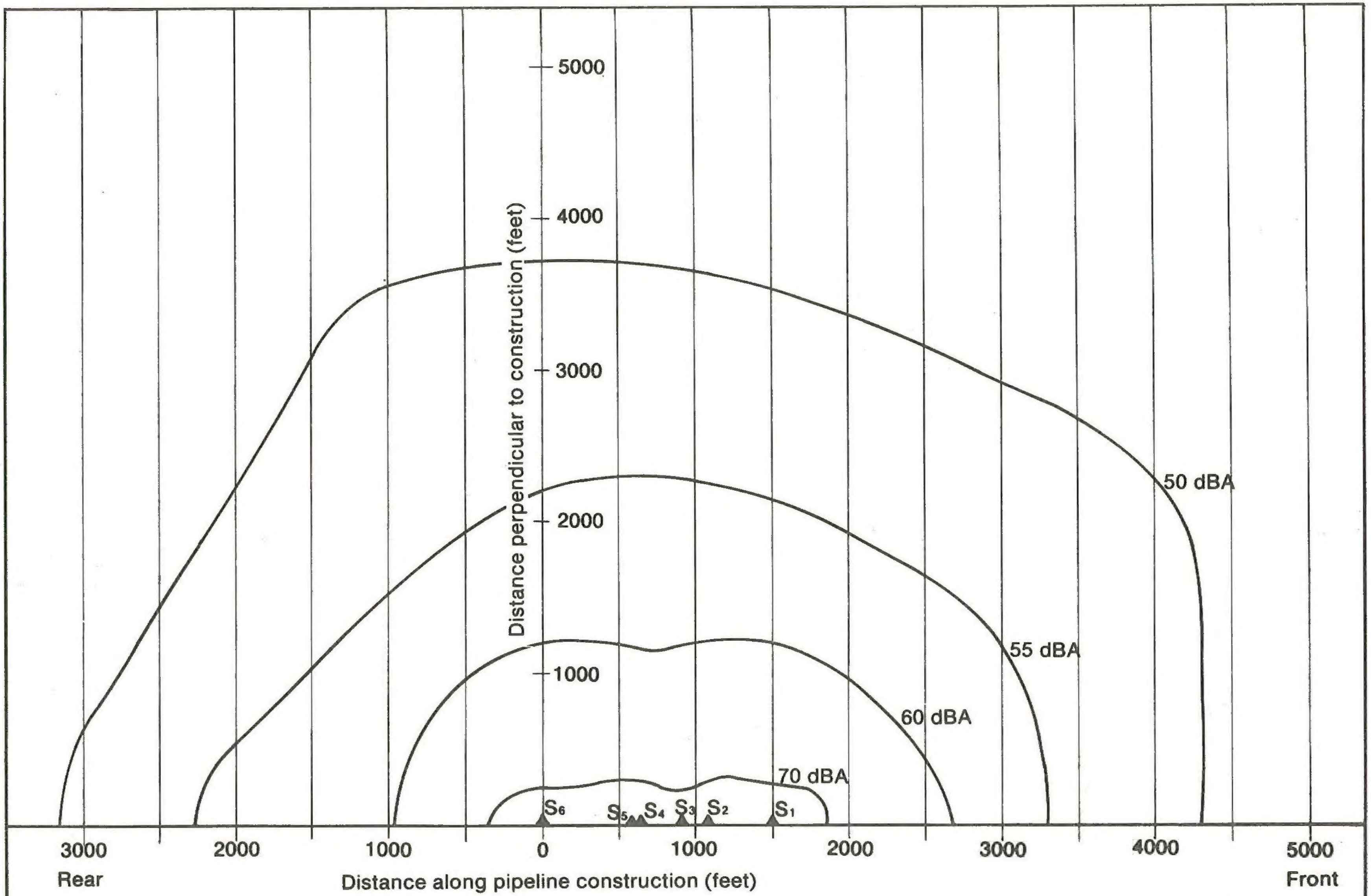


Figure A3.1.11.2.1-3 Noise levels from suburban pipeline construction scenario

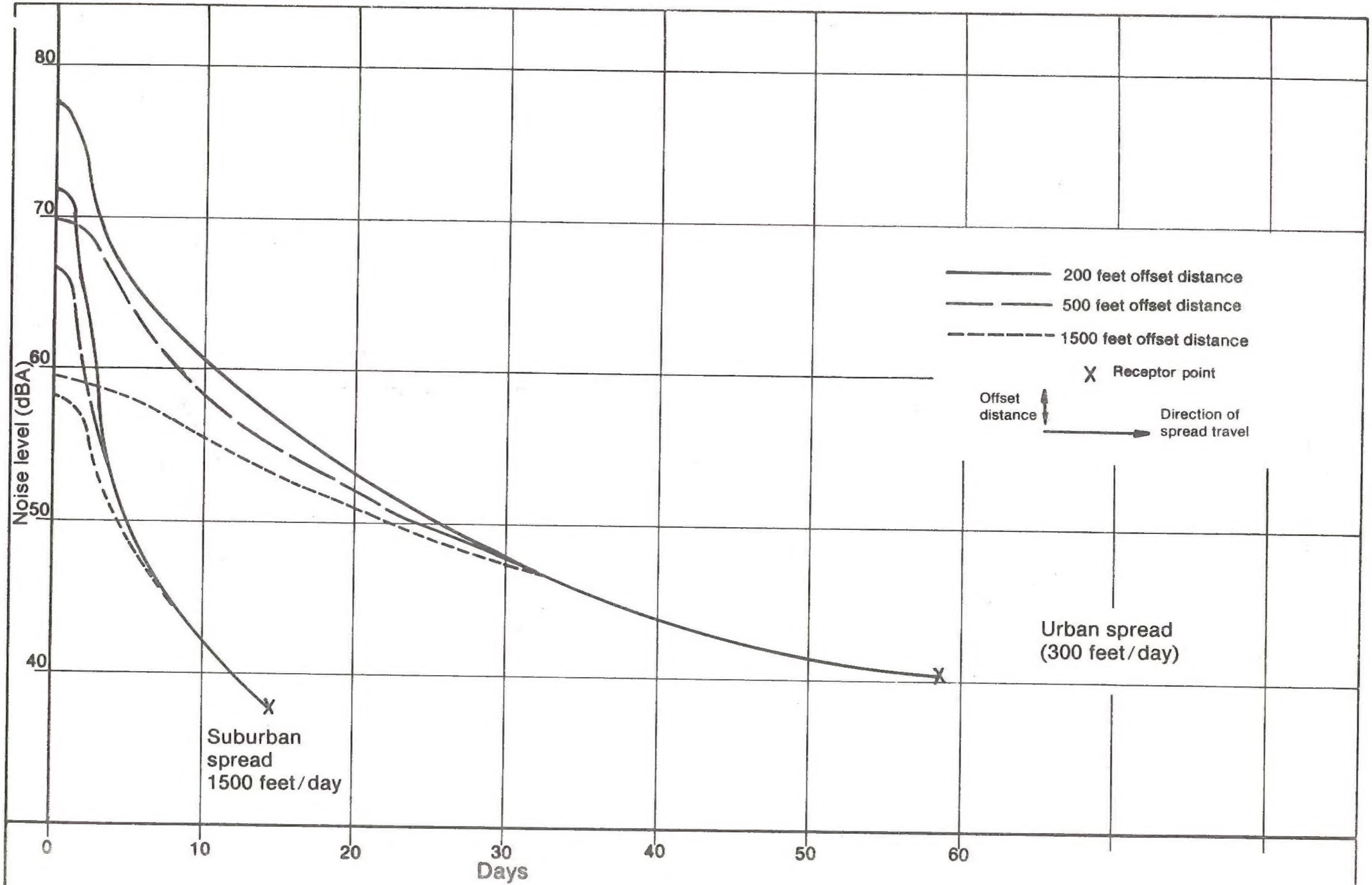


Figure A3.1.11.2.1-4 Approximate period during which indicated construction noise level is exceeded

for a maximum of three days in those areas where spread rates are greater than 1,500 feet or more per day. In those areas where the spread proceeds at a 300-feet-per-day rate, 60 dBA may be exceeded for approximately 10 days.

Table A3.1.11.2.1-1 summarizes the periods during which noise impacts will be experienced in various urban and suburban environments in California.

Table A3.1.11.2.1-1

Computed Duration of Possible Noise Impact as a Function of Existing Noise Level

DAYTIME NOMINAL NOISE LEVEL AT SENSITIVE RECEPTOR (dBA)	Duration of Possible Noise Impact (days)	
	Urban	Suburban
75	0	0
70	1-1/2	0
65	3	1
60	5	2
55	8	3
50	15	3-1/2
45	25	5

The table is based on receptors being less than 200 feet from the route and shows that in urban areas (typically having daytime noise levels of 60 dBA), the maximum duration of any noise impact is approximately five days. Lower ambient noise levels generally occur in areas of less intense development and where there are fewer obstacles to slow down pipeline construction. For example, a quiet suburban area, with a daytime median noise level of 45 dBA would have a maximum of five days of possible noise impact. The two factors cancel out in this case, resulting in approximately the same degree of noise impact.

There are a few relatively quiet (55 dBA or less) areas where pipeline construction would be expected to proceed at the slow "urban area" rate of 300 feet per day and where the duration of impact may be in the vicinity of 10 days.

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